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The Journal of Thoracic Surgery

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Original Communications

GENERAL PRINCIPLES OF THE SURGICAL TREATMENT OF PULMONARY TUBERCULOSIS

H. MORRISTON DAVIES, M.D., M.CH., F.R.C.S.*
RUTHIN, NORTH WALES

WITH the growth in knowledge and the gradual, sometimes rapid, addition to our technical means of investigation, greater precision has been given to certain aspects of diagnosis both as to character and extent of the disease, and also as to the reactions of the body to it. Yet, because of this very increase in technicalities, there is the risk that that priceless possession of our forbears, that asset in diagnosis, clinical instinct, may become submerged under the plethora of scientific facts and formulas. There are, moreover, already faint indications that, in the course of time, the patient may be passed through a series of independent tests and investigations, at the end of which the diagnosis, prognosis and a course of treatment will be almost automatically prescribed, without that individual, human, comprehensive survey and consideration which means so much to the patient, and without sufficient appreciation of the mental make-up of the individual; an aspect of the case of particular importance in a chronic disease like tuberculosis.

There is probably no disease in which the economic factor plays so important a rôle. Pulmonary tuberculosis is characteristically not a disease which affects the affluent and leisured class; and, even when it does, there is often a psychologic element which prejudices treatment. The result is that treatment is frequently a compromise between the ideal and an endeavor, in some greater or lesser measure, to meet the economic necessities of the case, and the mental discord

*From the Vale of Clwyd Sanatorium.

Read before the Eighteenth Annual Meeting of the American Association for Thoracic Surgery at New York, June 3, 4, 5, 1935.

of the patient. These difficulties have constantly to be taken into consideration when deciding on treatment.

It may be said that there have been two phases of sanatorium treatment. The first when rest, alternating with exercise, fresh air and a superabundance of food was the vogue. The second, the modern progressive one, when sanatorium treatment and bed rest tend to become considered but a background for active surgical intervention: a result of the advance in science and of the restlessness of the age. It has taken time to educate the public to modern advances, and now the feeling is growing among the public that bed rest only can scarcely be called adequate treatment and that time is being wasted if active steps are not taken. They have become eager disciples for artificial pneumothorax, for gold salts, or even for tuberculin, according to the predilection of their physician.

Now the actual technic of induction of an artificial pneumothorax is comparatively simple, as is also the maintenance of the collapse, until such time as complications may develop. It is therefore an effective method of fulfilling the wish of the patient for some tangible form of treatment. Artificial pneumothorax carries with it, moreover, the possibility of brilliant success: a complete collapse abolishing the symptoms and camouflaging the presence of active disease until such time as it is healed. Such a perfect result, however, can, as we know, be obtained only if there is a free pleural cavity, a comparatively rigid mediastinum and an absence of complications: conditions all too frequently absent.

While the results of a successful artificial pneumothorax are so satisfactory that they can be accepted without argument, there are those cases in which the collapse is only partially successful on account of adhesions. Not infrequently it is the diseased portion of the lung which is the least influenced by the pneumothorax: that is to say a "contra-selective" collapse is present, to use Gravesen's term. Temporary improvement may be associated with diminution of symptoms but the persistence of a cavity: the patient is, however, content, deceived by a false sense of security which may sooner or later be rudely shattered. The other serious group of complications, effusions, tuberculization of the pleura and empyema with possibly bronchial or cutaneous fistula, threatens the patient's life in a less insidious but in a more urgent manner.

It may of course be possible, in the case of adhesions, for the expert either to convert the partial into a complete collapse by the division of them; or, if this is impracticable, to supplement the artificial pneumothorax by phrenicectomy or thoracoplasty. The adverse course of effusions may also respond to treatment by comparatively simple or by more serious measures necessitating, at times, multiple operations.

Since even when under the watchful care of the expert from the inception of treatment, it is not always feasible to avoid the misfortunes of an unsuccessful artificial pneumothorax, the possibility of adverse results must be greater at the hands of those less experienced. With a treatment that has become so universal, it must be recognized that there is necessarily great difficulty for many to know when to admit that a line of treatment, seemingly successful at the outset, is of no material benefit; or to realize that a complication like effusion, apparently benign when first developed, is becoming a serious menace to the patient's life.

It is with these facts in mind that I wonder how right we are in advocating artificial pneumothorax in all early cases; an advocacy which is being increasingly made on the ground that adhesions, the main origin of these complications, are less likely to have developed.

The indications for artificial pneumothorax may be divided into two groups: indications of necessity and indications of choice. In the first group would be included patients with hemoptysis, those with pneumonic tuberculosis, and all cases of the exudative or mixed types in which the disease progresses despite bed rest; also all patients who, improving at first, relapse while under treatment; and some patients with less acute, mixed type of lesions with multiple cavities or a single large cavity; provided always there are no contraindications.

With the modern trend for active intervention, with the difficulties due to economic conditions, the pressure on beds, and the waiting lists which have led to the trial of artificial pneumothorax on ambulatory patients; with the necessity of early return to work if the post is to be kept, or if the one-man business is not to crash, there is a tendency to overlook the wonderful recuperative power of the body if treated solely by bed rest and sanatorium regimen.

There is a considerable percentage of cases which do not come into the category of indications of necessity, but into that of indications of choice: patients with early apical or subapical lesions of the exudative or mixed type; patients with more extensive disease, mixed or proliferative, with or without cavities small or medium in size and with comparatively thin walls. Many of these will respond progressively to bed rest without exacerbation of serious consequence or extension. According to the extent of the lesion they either heal completely, aided possibly by a phrenicectomy, or recover up to that point where, having acquired a degree of immunity, they are left with a localized lesion of the proliferative type, often with an apical or subapical cavity. This can then be treated by a limited thoracoplasty whereby to overcome the mechanical changes, to obliterate

existing cavities, and to produce a healing which defies relapse more effectively than by artificial pneumothorax.

The delay of one, two or even of three months, while watching the reaction of the patient and the response of the disease to bed rest, can but seldom make that insurmountable difference between a free pleural cavity allowing complete collapse by pneumothorax, and the development of adhesions which so interfere with the collapse that it is valueless. I exclude from this category those patients with superficial cavities of recent development with a surrounding zone of consolidation, which must be dealt with by collapse at the earliest possible moment. Except for these and certain patients with pleurisy, the time of onset of adhesions is usually unknown. The earliest recognizable apical lesion may have universal adhesions of that lung, while a patient with a history of even five years' duration and dense sclerosis may permit of complete separation of the membranes.

My belief is that by careful, individual selection, there is, for a considerable number of these patients, ultimately a saving of time by treatment with initial bed rest, and later, if necessary, some form of plasty; and that this is preferable to the generalized use of artificial pneumothorax with the dangers attendant on the exposure of the pleural cavity to infection, and the risks of relapse or of dissemination in an individual sent out into an unsuitable environment with the disease still active but camouflaged. When a pneumothorax is done, it must fulfill its purpose, or be supplemented or abandoned.

Modern technic has very considerably reduced the complications associated with the division of adhesions. The greater surety of preventing or of arresting hemorrhage by coagulation has widened the field of operability. For the division there has been a general tendency to revert to the actual cautery instead of diathermy. One of the biggest advances has been the technic of enucleation which enables short, thick adhesions containing lung substance to be separated without the danger of subsequent sloughing or of direct injury to the parenchyma. While the division of adhesions through an open incision has met with a measure of success, the principle is one open to certain serious objections.

Gomenol in conjunction with olive oil or paraffin is still on trial. It has unquestionably proved of great benefit in the treatment of pyothorax, but it is most uncertain in its effect. While one patient will respond in a most gratifying manner, another is uninfluenced. There seems to be no half measure about it: either it is completely successful or it is valueless.

There are cases of effusion in which neither gomenol nor irrigation succeeds in checking the infection, whether it is a case of uncomplicated tuberculosis or of mixed infection. It requires balanced judg-

ment to decide how long the simpler methods of treatment of a tuberculous empyema can be persevered with without prejudicing the beneficial result of a thoracoplasty. When the contralateral side permits, the delay should be minimal.

I do not think sufficient use is made of air-tight syphon drainage when the patient is too toxic to justify a thoracoplasty and the need of aspiration becomes increasingly frequent on account of toxicity, of pressure symptoms, or of fistula. My experience is that an air-tight drain can be maintained for months if required, and that as it enables the infection and the pressures to be controlled, it affords the greatest relief. With this drainage the lung may moreover gradually reexpand and obliterate the pleural cavity, when a plasty may be advisable and possible. If the pleural membranes are too thick to allow of expansion and a plastic operation is contraindicated, complete closure of the track can often be obtained, once the pleural cavity is sterile, by gradually reducing the size of the tube.

In the matter of oleothorax in conjunction with pneumothorax I am in direct contradiction to the late Ray W. Matson. I still consider that oleothorax with paraffin and gomenol for the replacement of artificial pneumothorax may come into greater favor. The value of oil is that refills are seldom required, and unquestionably the permanence of the collapse adds greatly to the recovery and comfort of the patient; while the ultimate saving of time to both patient and staff is immense. Cases suitable for oleothorax require, however, most careful selection. I am entirely opposed to the use of oil in order to attempt to counteract the reexpansion of the lung by an obliterative pleurisy. The oil must never be at a positive pressure. The essential criterion of the justifiability of using oil to replace air is the retained mobility of the mediastinum during respiratory movements. If the oil does not immobilize the mediastinum during the period of replacement, it will not do so later. The oil pressure must be checked off periodically during the first six months to ensure that the negative pressure is being maintained; there appears then to be no further danger, and there is no need to retain a pocket of air above the oil. I have several patients in whom the oil has been left in for years. One of those replaced by oil six years ago has since had her gallbladder removed, and another replaced five years ago has had a hysterectomy, both operations being tolerated without incident. Let it be clear that I am not advocating oleothorax as an alternative to thoracoplasty.

The above statements indicate that oil does not necessarily cause thickening of the pleural membranes and assist in immobilizing the

mediastinum. Oil and gomenol are full of contradictions. As a means of fixing the mediastinum and of obliterating small fistulas, oil may be of immense service.

Few operations can have come into such rapid and general use as that for severing the continuity of the phrenic nerve. The method used should always be the radical operation or the crush; and never, in my opinion, that of evulsion. Of the 26 fatalities collected by Berry, at least 20 can be attributed to evulsion. The 20 include the 12 cases of "pneumonia with tuberculous dissemination." These I consider were caused by the lift of the dome during the drag on the nerve squeezing secretion out of the lung into the bronchial tubes. This secretion was then aspirated into the lower lobe by the sudden descent of the dome when the nerve filaments gave way.

There is too great a tendency at the present time to regard phrenic nerve interruption as a radical operation for the cure of tuberculosis. In consequence, disappointment has been expressed at the results, and the value of the operation decried. Phrenic nerve interruption should be considered as auxiliary and ancillary to other methods of treatment. Used correctly it is of immense value in a considerable number of cases. As, however, the height to which the dome will rise cannot be foretold, so is the influence on the disease in any particular case indeterminable. When considering statistical results the right attitude is adopted by Nehil and Alexander by their phrase "expectation was fulfilled."

Phrenic nerve interruption is indicated (1) for its influence on the lung; (2) for its influence on pleural lesions; (3) for its influence on symptoms; (4) in conjunction with other operations. As the elasticity of normal lung tissue will always take advantage of any opportunity to contract, in marked contrast to lung substance involved by consolidation or exudation, the operation is contraindicated for lesions associated with these changes. On the other hand, the contractile force of fibrous tissue being infinitely greater than that of elastic tissue, it is among the proliferative type that cases suitable for phrenic nerve interruption are found.

It must not, however, be expected that a phrenic nerve interruption is going to be of value in all cases of proliferative tuberculosis. If the apex is bounded by thickened pleural membranes, and particularly if there is a dense interlobar band of adhesions stretching from root to periphery, change in the lower thorax is unlikely to be transmitted to the upper segment. Nor under these circumstances can it be expected that a cavity will be materially influenced even by a high rise of the dome, especially if the cavity be surrounded by thick walls or consolidated lung parenchyma. It is obvious, therefore, that when

artificial pneumothorax fails, phrenic interruption is by no means necessarily the second line of attack.

On the other hand, I would emphasize that a phrenic interruption may be done in some cases with great advantage as an alternative to artificial pneumothorax. It is certainly worth trying as the first line of attack for the moderately localized proliferative lesion, with or without a small, thin wall cavity, whether of the upper or the lower lobe, which has responded up to a certain stage, yet incompletely, to bed rest. It is also indicated as an alternative to bilateral artificial pneumothorax when there is a thin wall cavity in the lung contralateral to that already under treatment by artificial pneumothorax. For the treatment of hemoptysis Nehil and Alexander place phrenic paralysis as their first choice of collapse procedures.

I am not sure that the value of phrenic interruption for the treatment of symptoms is sufficiently appreciated, irrespective of whether the disease itself can or cannot be benefited. The chief symptoms which can be alleviated are the pain or dragging ache following a basal pleurisy, the diaphragmatic cough due to basal adhesions, tachycardia due to pleuropericardial diaphragmatic adhesions, and even morning vomiting. Carlson and others failed by clinical experiments to find support for the contention that cough and expectoration are facilitated; but in the face of the evidence from postoperative observations I am not converted.

The value of phrenic interruption to supplement an incomplete artificial pneumothorax, or to control the base when an obliterative pleurisy has started, or to reduce the hemithorax at the termination of the collapse treatment is recognized; but it is by no means fully recognized what a great influence phrenic paralysis can have in cases treated by artificial pneumothorax in aiding the obliteration of suspended cavities which are failing to respond to the pneumothorax. I doubt, however, that paralyzing the dome can have any effect on effusions except that it may relax adhesions which were the original cause of that effusion.

A phrenic interruption as a preliminary to a thoracoplasty is, in my opinion, justified only if it is considered necessary to obtain further preliminary improvement in the patient's general condition. The interruption of the nerve fibers should, therefore, be by crush only. I consider it most unwise to have a permanent paralysis of the dome with a complete thoracoplasty, as this means that the collapsed, passively congested lung is entirely surrounded by fixed, immobile walls, allowing no variation in the degree of congestion.

The writings of Hoover and of Gale and Middleton among others, and later the first results published by Fisher, made it seem possible that division of the scaleni muscles with mobilization of the first rib

would aid materially or later supplement the effect of a phrenic interruption in the treatment of apical lesions. My feeling on reading Fisher's last paper written in conjunction with Hill is that while considering the operation as frequently a definite adjunct to phrenic nerve interruption, he himself is somewhat disappointed in the results. My own experience is very much smaller, being only 35 cases. It was only natural that in certain cases one expected somewhat greater benefits than from a simple phrenic interruption. The results have been most discouraging and do not seem to justify the additional operative measure. Alexander has, however, recently called my attention to the possible value of scaleneotomy in conjunction with intercostal neurectomy.

During the last eight years or so, surgeons have shaken themselves free from the fetters associated with thoracoplasty. It has been realized that the original stereotype operation inflicted an unnecessary collapse of healthy lung tissue in some cases, and in others, especially those with large cavities, failed to produce the necessary completeness of collapse. Now that the character and the extent of the plastic operation are varied to suit the requirements of each individual patient, it is the most satisfactory, the most efficient and the most "radical" operation for healing tuberculous lesions.

The deadly nature of cavities demands not only the relaxation of the walls, but also their approximation. The pleural membranes over a large cavity are almost always fused, so that an artificial pneumothorax is valueless and a phrenic interruption is frequently of no avail. Modern thoracoplasty aims at the complete decostalization of that part of the thorax overlying the cavity. In quite recent years we have come to recognize two general principles. The first is that however large or thick wall a cavity is, it is generally possible to obliterate it provided the endeavor is sufficiently vigorous and efficiently planned. The second is that when need arises the complete removal of practically all the upper ribs and the costal cartilages, the transverse processes and even, if need be, part of the sternum, can be tolerated by patients provided the removal is done in a sufficient number of stages. But there is an important proviso. The cases must be selected with full regard to the character of the lesion, with the assured absence of recent exudative foci and with consideration of the individual resistance of the patient.

The principle of thoracoplasty is so generally recognized by all who have had any experience that it has ceased to be a matter for discussion; but there is no such unanimity on the question of technic. Each surgeon has his own individual ideas on the many important problems, such as the extent of the operation, the number of ribs and the extent of bone to be removed at one stage, the total number and the

total length that should be resected, the number of stages, and even the order thereof. Experience in the variations of these problems is of such comparatively recent date that the evidence is still insufficient. There are still the disappointments of persistent cavities, of persistent positive sputum; there are still fatalities. It will require some years yet and considerable further experimentation and disappointments before we arrive at a satisfactory and fairly universally accepted solution of these present problems.

It is scarcely necessary to stress to surgeons the great advantages that a localized, and in some cases a generalized, thoracoplasty has over artificial pneumothorax. Admittedly it is more drastic and the immediate risks are greater, but once accomplished there is a much greater assuredness of success if the operation has been planned adequately to meet the necessities of the case. With artificial pneumothorax there is never a complete sense of ease until the lung has reexpanded, and not even then. When troubles are not actual, they are potential. There are the difficulties associated with incomplete collapse; there are the efforts which may or may not be successful to overcome these; there are all the disturbances and possible dangers associated with effusions; there is the long-drawn-out period of refills during which an obliterative pleurisy may develop or a fresh area of lung become infected from the unhealed cavity. Admittedly with a thoracoplasty the step is an irretrievable one, so that the care in the selection must be impeccably exacting. The danger period of the operation over, however, the efficiency and the constancy of the control are assets unattainable with artificial pneumothorax.

The principle of utilizing a solid foreign body, such as paraffin, to maintain an extrapleural collapse, as in apicolysis, is not a sound one. If that foreign body is exercising a compression force and is surrounded by immobile, unyielding structures, anxiety for the tolerance of the opposed lung and pleural surfaces is considerable. Yet it must be admitted that most excellent results are obtained and that paraffin apicolysis offers a means of collapsing apical cavities in certain cases in which the immediate risk of a thoracoplasty seems unjustifiable. Theoretically the paraffin is so inserted that it merely fills the extrapleural space; yet compression may result from the reexpansion tendency of the lung or from an associated effusion.

An apicolysis should never be considered so long as a thoracoplasty is a fair risk, but when indicated it offers a valuable possible method of saving life and of healing the disease.

Now that experience has established the principle of all these surgical measures, it has been proved that with increase of refinements in technic practically every combination of operation is possible for the treatment of bilateral disease in selected cases.

It is only a comparatively few years ago that the surgical treatment of pulmonary tuberculosis was still regarded as wholly impracticable except by a very few, farsighted enthusiasts. Since then such enormous advances have been made that it is only a very small arteriosclerotic minority that refuses to recognize them. The progress of thoracic surgery has been more rapid than that of any other branch of surgery or medicine. But it may be well to remember that it has only started to develop its strength, that operations which today we consider impracticable may prove in the tomorrow to be of immense value, and that methods of attack on the disease not even yet conceived may become an established routine a few years hence. It is right to be critical of every operation and of every detail in technic; it is wrong to condemn without its fullest trial. Already operations have waxed and waned and then returned to fade out as some new knowledge in anatomy or in technic has altered the balance of the scales.

One more general principle must be mentioned. Every means of investigation and every facility for carrying out the treatment must be available for those who may be fit subjects for the major operations. This suggests the necessity for completely equipped institutions either actually in or within reasonable access of cities. Yet to transfer a patient from the pure air of a country sanatorium and from the control of those who have studied his particular case, into the care of strangers and into the vitiated oppressiveness of a large city is placing a handicap on the successful issue.

In this connection the figures of Dr. André Maurer who operates both in Paris and in a group of Swiss sanatoriums are most instructive.

Of 130 patients operated on by thoracoplasty in the Swiss sanatoriums there were 80 per cent good results and a 10 per cent mortality. (This is not an immediate mortality.) per contra

Of 102 cases similarly treated in a city hospital, the good results were only 56 per cent and the mortality 26 per cent.

It necessitates a greater waste of time for the surgeon in travelling and a very competent resident in the country sanatorium, but the above figures are strong evidence of the value of the completely equipped country institution.

One final general principle—in no branch of surgery is it more important than in thoracic surgery that the surgeon must be his own physician.

THE CHOICE OF PROCEDURE IN COLLAPSE THERAPY*

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THOSE who accept tuberculosis as an acute, communicable disease, in which most destruction of lung takes place in a few weeks or months, will undertake to treat patients immediately with some form of collapse therapy to stop the spread of infection, to assist in cavity closure, and to cause an arrest of the disease. Some few patients get well without this assistance, but thousands die because they do not receive it, and thousands of others become infected from those who are neglected and allowed to cough up positive sputum for months or years. The early use of the knowledge and procedures we have today, if properly applied, could eliminate tuberculosis as a serious menace to society, and this, I think, should be the goal toward which we strive.

Our best opportunity to control the disease exists in the treatment of early minimal lesions. Yet today, even in the centers most actively concerned in the management of this disease, 80 per cent of patients are advanced when first seen. If the medical profession and the public as a whole would shake off their lethargy regarding this disease, forget Osler's symptoms and stethoscopes, and establish a universal system of case findings with the use of tuberculin tests and x-ray examinations, these advanced patients would be rapidly reduced in numbers; and, if the hospitalization and immediate treatment by collapse therapy were then accomplished, the whole picture of tuberculosis would be changed.

We cannot tell when we first see a patient what course the disease will take; and many, even though hospitalized, if left to bed rest alone will progress rapidly into far-advanced disease. The practice of waiting a few months to see which way the disease will go does more to undermine the management of tuberculosis than any other factor, for, when this is recommended and practiced by those supposedly qualified to treat the disease, it is misinterpreted by the public and many of the profession. As a result, patients are left at home without proper check-ups and, in many instances, needlessly develop far-advanced disease. We should, therefore, begin immediately with the simplest of our procedures, and add others as soon as the first shows itself incapable of adding enough assistance to cause closure of cavities and arrest of the disease.

*Read before the Eighteenth Annual Meeting, of the American Association for Thoracic Surgery, New York City, June 3, 4, 5, 1935.

While we all recognize that patients with tuberculosis go through various phases, there is no phase of the disease in which collapse therapy is not indicated except in the terminal one when it is too late. Unfavorable blood counts, sedimentation tests, etc., therefore, do not contraindicate its use, for in many instances the blood picture which shows lowered resistance will change to a normal picture immediately following collapse therapy. The more drastic procedures, of course, should be used more carefully in this stage of the disease.

With early unilateral lesions, where adequate hospital facilities are available, the decision must be made as to whether phrenic crushing, phrenicectomy, or pneumothorax should be used. Here an honest difference of opinion exists, and the choice is often difficult to make. However, in early, soft, infiltrative lesions, and in those with small cavitation up to 2 or 3 cm. in diameter when the disease is not spreading rapidly, in fanlike lesions at the apex, in moth-eaten cavities, and in productive lesions with small cavitation, phrenic operations are usually preferable. Whether these be temporary or permanent is today a point of much discussion. Certainly, phrenic crushing leaves no permanent loss of function which might be regretted later, but it does not permit as much uniform rest and relaxation as a permanent phrenicectomy, the fears of which seem to be overemphasized. There are some definite lesions in which there can be no question as to procedure. In the early infiltrative lesion without parenchymal destruction and cavitation, crushing is advisable, for many of these heal early by resolution. If parenchymal destruction, however, has taken place, and much cavitation exists with positive sputum, phrenicetomy is usually indicated, for there is always danger that the cavity closed by crushing will reopen upon regeneration of the nerve and remain so for some time before it is discovered, with the sputum again becoming positive. I have seen many patients in whom this had occurred obviously many months before it was discovered, and the nerve recrushed. This may seem avoidable, but in hospitals with large numbers of patients and rotating resident physicians, and the problem of frequent early return of diaphragmatic function, together with patients leaving the hospital without proper supervision soon after the crushing, it frequently occurs. The nerve may be recrushed, of course, but this cannot be kept up indefinitely, and for the reasons cited patients may not always be seen when recrushing is indicated. The operation also becomes much more difficult at each recrushing, and there occasionally occurs little or no paralysis after the second crushing. Accessories which come off the brachial roots outside the operative field are, of course, responsible for this occurrence.

Advocates of crushing wish to avoid a phrenicectomy because disease may occur later on the opposite side. They usually are willing, however, to perform a phrenicectomy after a few months'

trial with crushing. The danger of disease occurring in the contralateral lung is still present, and always will exist. If withholding phrenicectomy for this reason is sound, it should never be done. It is usually better to disregard the possible occurrence of disease in the contralateral lung and to concentrate on lesions present when first seen, to close cavities, and to maintain closure with some permanent procedure rather than use temporary measures which allow some degree of motion for variable periods of time, for there are fewer contralateral spreads as well as lower incidence of reactivation of disease on the operated side following phrenicectomy than following crushing.

If disease does occur in the contralateral lung following phrenicectomy on one side, all is not lost; for in all parts of the country are hundreds of patients with bilateral pneumothorax, bilateral phrenicectomies, or a combination of both, and often with thoracoplasty as well. Much attention is given to some isolated patient in whom a phrenicectomy had been done, which may have embarrassed treatment at some later period, but the dangers from crushings just cited are usually overlooked. We rarely have regretted that a phrenicectomy had been done, but often wished that our crushings had been phrenicectomies. While I believe, therefore, that in the lesions just described, phrenicectomy is preferable, there can be no serious objection to one crushing if the dangers from its use are kept in mind, and careful and frequent check-ups are made for motion of the diaphragm. If it be necessary or advisable to recrush, however, I believe phrenicectomy should always be done if the lesion is unilateral.

Phrenic nerve operations, of course, will not take care of all the lesions just mentioned, but they will suffice for many of them, and a trial should be given them before pneumothorax is undertaken. There are those who minimize the value of phrenic operations, but in spite of the misleading statements of those inexperienced with their proper use, phrenic nerve operations are indispensable in the proper management of pulmonary tuberculosis. A patient, however, should not be given a phrenic operation, and then left at bed rest for an indefinite period in the hope that this procedure will accomplish the closure of cavities ultimately, but if it is not apparent in a few weeks from the roentgenogram that the cavities are closing rapidly, a pneumothorax should be added. No time is lost in this attempt for there is, as a rule, as much reduction of lung volume, and as much rest given to the lesion immediately after a phrenic operation as occurs for two or three weeks following the induction of pneumothorax, and if pneumothorax is then added immediately, the patient will receive the benefit of both procedures. If this routine is carried out, it will be difficult to evaluate the results of any particular procedure, and this is as it should be. One should not try to weigh the results of one

procedure against the others, but rather to look at the picture as a whole, and evaluate the results of collapse therapy.

There are many patients upon whom pneumothorax is added following a phrenic operation where, in time, the cavity would have closed without its help. Time, however, is an essential factor, the disease is a communicable one; and, as long as sputum is positive, the patient is a menace to himself and others. It might seem consistent, on this ground, to induce pneumothorax on all patients at once, but it is not always effectual, is a much more burdensome procedure, has many more complications, and can often be avoided without allowing undue delay in cavity closure. In many patients, after pneumothorax, the diaphragm is pulled up, fixed, and functionless, or a phrenic operation is advisable anyway to maintain healing. It is best when possible to try a phrenic operation first, therefore, in the hope that pneumothorax may be unnecessary.

In those patients, however, with unilateral, rapidly spreading, soft lesions, or with multiple or large cavitation or extensive disease, in acutely sick febrile patients, in tuberculous pneumonia, and in productive lesions with large, thick-walled cavities, it is usually useless to attempt a trial at phrenic operation, and pneumothorax should be instituted at once. In these patients, however, if pneumothorax is impossible or if proper collapse cannot be obtained with it, a phrenic operation, temporary or permanent depending upon the extent and character of the lesion, should be added. If the disease is confined to the upper third of the lung, especially with large cavitation, crushing is preferable, for if a phrenic operation is not effectual, we may then wish to do an upper stage thoracoplasty and allow the diaphragm to resume its function. If, however, after a crushing, a large apical cavity is reduced in size and contour, phrenicectomy and as limited an upper stage thoracoplasty as necessary is done. It is better to have a phrenic operation which is assisting in cavity closure, and limited thoracoplasty than complete thoracoplasty without the phrenic treatment. If disease with cavitation exists throughout the entire lung field, phrenicectomy is usually indicated. If large cavitation, however exists in the upper lung field, and there is only an infiltrative lesion at the base, crushing is preferable, for the base may clear by resolution, and the problem will then be the same as in those patients with only apical cavity.

The treatment of bilateral disease requires special consideration. In future years, it will, I hope, be little needed, for almost all these patients passed through a stage when the disease was unilateral and easily amenable to treatment. Bilateral collapse is very complicated, and one must feel one's way, juggling all procedures in many ways to cause ultimately the closure of cavities.

We prefer, as a rule, in bilateral disease to begin with pneumothorax on the worse side. There are some patients, however, in whom the disease is so limited and of such character in both lung fields that this may not seem advisable. If there is only very small cavitation on the worse side, and a very small, light, infiltrative, soft lesion or some fibrosis in the other lung, a phrenic crushing may be advisable on the worse side. If the lesion in the contralateral lung does not clear satisfactorily, a crushing should be done on that side also. Phrenicectomy on one or both sides may be done later if this appears necessary or advisable. With lesions slightly more extensive in both lung fields, pneumothorax is attempted on the worse side, and, if this is possible, a crushing is done for the lesion in the contralateral lung. If pneumothorax is impossible of accomplishment on the worse side, the procedure is reversed, and pneumothorax started on the contralateral lung, and a phrenic operation, temporary or permanent according to the lesion, done on the worse side. Pneumothorax on one side and phrenic operation on the other are preferable to bilateral pneumothorax because less hazardous, less burdensome to the patient, and the dangers of spontaneous pneumothorax, fluid, etc., are lessened. There is a marked tendency toward clearing in the contralateral lung following collapse in the opposite side. Because of this, therefore, lesions in the contralateral lung for which a pneumothorax may have seemed necessary may often be controlled by a phrenic operation.

If extensive disease with cavitation exists on both sides, however, it is better to begin bilateral pneumothorax early without the use of phrenic operations to minimize as much as possible the dangers of spontaneous pneumothorax, which is much more serious if it occurs in the contralateral lung after the other lung has been greatly collapsed. In these patients, crushings, which are almost always used in bilateral disease, may be necessary later on one or both sides to assist the pneumothorax in cavity closure.

In those patients in whom thoracoplasty is indicated on one side, and there exists small cavitation in the contralateral lung, pneumothorax should be instituted for this contralateral lesion before thoracoplasty is performed on the worse side. One must be sure that the disease in the contralateral lung can be controlled before subjecting the patient to this ordeal. It is better to establish the pneumothorax prior to the operation for, if spontaneous pneumothorax occurs in the attempt, it will be less serious than afterward. A small cushion of air is all that is desirable, for, after the operation has been completed, it may then be continued with greater safety. Pneumothorax is preferable to phrenic operations in these contralateral lesions because it is more easily controlled.

In patients undergoing pneumothorax treatment, adhesions are encountered frequently. These are more numerous in those patients who

are not treated or are left to bed rest alone in the early course of the disease. Their mere presence, however, does not mean that they are holding cavities open nor that they should be severed, for many of them do not retard collapse. If they are doing so, the use of phrenic nerve operations, and positive pressures if necessary, in bed patients, will overcome most of them. The use of positive pressures to stretch adhesions may seem hazardous, but a survey at Herman Kiefer Hospital, where it is used extensively, showed that not one spontaneous pneumothorax had occurred over a period of seven years from this cause. If cavities are remaining stationary in size after phrenic nerve operations and positive pressures, and adhesions are obviously the cause, they should be severed unless they are encountered during collapse of a lung with multiple or large cavitation which probably cannot again function safely. In these patients thoracoplasty is preferable to repeated trials at cauterization.

While I believe this sequence of procedures in the management of tuberculosis is the ideal, it is much more important that cavities be closed with some procedure as soon as we see a patient with active disease than that this sequence be followed.

It is often necessary to adjust collapse therapy to suit local and individual conditions. In many communities, adequate hospital beds and other facilities for proper treatment are not available, and ambulatory pneumothorax treatment, although not ideal, has become necessary. Many patients also, such as the Negro, Indian, Mexican, etc., who have not a long hereditary resistance to the disease, must be overtreated, and special consideration must be given to children in the teen age, to pregnant women, and to those who do not wish to become charity patients, and yet can afford only a short period of hospitalization. Exceptions must also be made for patients who are hemorrhaging when first seen or who have other complications, such as emphysema, serious cardiac disease, etc.

Under any circumstances, however, if cavities are not closed with phrenic nerve operation, pneumothorax, pneumonolysis, or a combination of these, thoracoplasty is usually necessary. In these borderline patients, however, in whom the above procedures have not entirely succeeded in controlling the lesion, and in patients who may be considered too poor risks for thoracoplasty, scaleniotomy, and multiple neurectomy, paraffin and other forms of extrapleural packs are sometimes advisable. There have been some very optimistic reports regarding the results of scaleniotomy in small apical cavities, but the procedure has not been generally accepted. In most thoracoplasties, the entire first three ribs are removed at the first stage, and yet only occasionally following this stage are cavities closed. It is difficult, therefore, to understand how merely cutting the scaleni can frequently accomplish this result. It has usually been performed in con-

junction with a phrenic nerve operation, and probably, in many instances, the result was obtained from this procedure.

Intercostal neurectomy, in the hands of Alexander and some others, has been of benefit in those patients apparently too sick for thoracoplasty, but it has not been used extensively. It is believed generally that in most patients upon whom it might be indicated, a limited Sauerbruch operation in multiple stages could be done, causing a great deal more rest and collapse.

Paraffin and all other forms of extrapleural packs, I believe, should be reserved only for that class of patients who cannot undergo thoracoplasty. I have found very few indications for their use. The principles of collapse therapy are based on relaxation, not compression. Therefore, I think these procedures are basically unsound. I am also prejudiced against leaving a foreign body in the chest.

Patients upon whom thoracoplasty would be required will, I hope, like those needing bilateral collapse, be rapidly reduced in numbers in the years to come. Most of these patients also represent a mistake or neglect somewhere early in the course of the disease.

The classical indications for thoracoplasty are in those patients with chronic unilateral disease, where fibrosis, retraction of the trachea, etc., exist, and in whom all other measures have failed to control the disease. I do not believe, however, that we should wait for this ideal condition to exist when we see a patient, after the acute symptoms subside, with relatively early disease which cannot be controlled by simpler procedures. This is especially true in large, soft-walled cavities left after most of the parenchymal infiltration has cleared. If thoracoplasty is not done early in these patients, they become derelicts, a menace to themselves and others, while we wait for them to become good chronics. I have operated upon many such patients, and while I do not consider them as good risks, most of them do very well. In pneumonic, consolidated lungs, however, thoracoplasty should not be performed because usually proper collapse cannot be obtained; and, when excavation takes place later, it will be necessary to reoperate.

In some patients with very extensive, productive disease, with multiple or large cavitation when first seen, it may seem advisable to perform a thoracoplasty before using simpler measures, but even in these patients I believe a short period of treatment by phrenic surgery or pneumothorax when possible will often put the patient in better condition to stand the more serious procedure. If there is large cavitation and much sputum where there exists more danger of bronchogenic spreads, this is especially true. The use of these temporary procedures will occasionally obviate the necessity for thoracoplasty. Their use, however, in these patients should not be protracted, for

complications, such as empyema during pneumothorax treatment or bronchogenic spreads due to incomplete collapse, etc., may complicate matters.

Bilateral thoracoplasty is indicated occasionally in bilateral apical cavitation. With the early use of collapse therapy in all patients, however, and with the extensive use of pneumothorax and phrenic nerve operations in bilateral lesions, I believe it will seldom be necessary. I have never found it so.

It is frequently inferred that the management of pulmonary tuberculosis should be less mechanical than is suggested by this paper. There are still those who would fiddle while Rome burns—with idle discussions of acute benign, benign hematogenous, and other elusive phases of the disease which might not require collapse therapy; but, sad and humiliating as it may be, with our present knowledge, if we wish to eliminate tuberculosis, we must be mechanics.

DISCUSSION

DR. FREDERICK T. LORD.—As Dr. O'Brien has said, 80 per cent of patients admitted to sanatoriums have advanced tuberculosis. The campaign for early diagnosis as at present conducted is in large measure a failure. The explanation is to be found in the fact that in a large proportion of the patients with the disease in its early stages there are no significant symptoms or physical signs. During this period of latency, the diagnosis can be made only by the routine use of the x-ray or the routine use of the tuberculin test and x-ray examination of the reactors. The remedy is to investigate all members of the population, but, failing in this on account of the expense, the alternative is to select readily available groups and those with more than the average chance of the disease. In Massachusetts in the continuing program it is planned to have an annual investigation of all school children in the seventh, ninth, and eleventh grades. Such a project should also include an x-ray examination of all family contacts of the tuberculous children. The discovery of the disease may be expected in one out of every four or five such family contacts. In addition, all household contacts of tuberculous patients in sanatoriums and in the practice of physicians should likewise be investigated. Facilities for this purpose are fortunately available in Massachusetts and without expense to the patient, if necessary, through the state and county sanatoriums and by extension of their service to include regions not covered by municipalities. School-teachers should have an annual x-ray examination as a protection to the children. Nurses in hospitals should be routinely investigated with the tuberculin test and the x-ray examination at the time of enrollment, and the x-ray examination should be repeated semiannually with repetition of the tuberculin test in those previously negative. Furthermore, all diabetic persons should have an x-ray examination.

DR. NORMAN BETHUNE.—I should like to say a kind word for a paraffin pack. Dr. O'Brien apparently does not think very much of it. I believe it has a definite place in two conditions that probably are not well recognized. The first is that in a comparatively soft tuberculous lesion which is not suitable for thoracoplasty and pneumothorax is impossible, and that is perhaps hemorrhaging, it will often be a life-saver.

The second point about paraffin is that it is usually thought that paraffin is a permanent thing, but I am advocating the use of a temporary paraffin pack as a procedure before thoracoplasty. In other words, put in the paraffin, then wait for

six months or so; take it out when you do the thoracoplasty. We have had some quite good results using it in that manner.

Paraffin is supposed to be a compression form of therapy. It is not, at all. It is a form of relaxation therapy exactly as pneumothorax is. Paraffin does not press down, apart from its own weight on the lung. It only prevents the lung expanding which you have liberated by your digital separation. It does not actually press down on the lung any more than air presses down on the lung except by the difference in weight of the two materials.

DR. EDWARD D. CHURCHILL.—May I call your attention to a modification of apicolysis combined with thoracoplasty which has been developed and described by my friend, Dr. Carl Semb of Oslo. This procedure differs from the ordinary apicolysis in that the apex is mobilized in the extrafacial plane rather than in the extrapleural plane. I had the privilege of watching Dr. Semb last summer and was impressed by the complete dissection of the dome of the thorax. I have carried out this operation on some twenty-five cases this winter and have been more than pleased with the immediate closure of large apical cavities, the increase in the effectiveness of partial upper thoracoplasty, and its value in the very difficult situation presented by Dr. Kinsella of reoperation on thoracoplasty cases.

DR. E. J. O'BRIEN.—I should like to say a few words about Dr. Bethune's discussion. There are, of course, a few indications for the use of paraffin, but unfortunately one does not know just how much paraffin is necessary to close a cavity. As a matter of fact, the lung following paraffin filling acts exactly as following thoracoplasty; when you free the apex of the lung, it drops down and runs away, and you have no idea how far it will drop. Therefore, there is no way of accurately determining whether you are going to close a cavity or not. Patients undergoing pneumothorax treatment often have a cavity that stays open until you get it almost a hundred per cent collapsed. How you can tell how much paraffin to put in, I do not know. If compression were accomplished instead of relaxation, then paraffin and other forms of packs would, in my opinion, be of more use, but inasmuch as the relaxed lung contracts and pulls the cavity down toward the hilum, I think the procedure, except in isolated patients, will be disappointing.

LOBECTOMY IN PULMONARY TUBERCULOSIS*

Report of a Case

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Cleveland, Ohio

THERE are many fundamental objections to the use of lobectomy in the treatment of pulmonary tuberculosis. Localized tuberculous disease can usually be arrested by much less serious compressive procedures. The hilus of the lung is certain to be infiltrated so that an incision must be made through tuberculous tissue, with the risk of poor healing of the stump and persistent bronchial fistula. There would also be the danger of spreading the disease either locally into the hilus or mediastinum or generally through the lymph or blood stream.

In spite of these objections in principle, however, very occasionally we are confronted with a situation in which lobectomy might be considered a logical procedure or perhaps the least of many evils.

The disease is confined to one upper lobe which is densely infiltrated and contains a cavity of considerable size. The pleural space is free so that under artificial pneumothorax the lobe drops down to the region of the hilus. Under persistent treatment and with pressures as high as are feasible, the cavity does not decrease in size, in fact often increases, and the infiltration of the lobe remains dense. Yet there is no spread to other parts of the lung.

Case 1 illustrates the problem (Fig. 1). The patient, aged twenty-seven years, was admitted with evidence of mottled infiltration and ulceration, 3 × 4 cm., of the right upper lobe. Pneumothorax was started and the lobe dropped. Despite the use of positive pressures the cavity became larger and the lobe was densely infiltrated.

In such a situation a choice between the following procedures suggests itself.

A thoracoplasty with the lung in this position. Frequently, the upper part of the cavity is as low as the seventh rib posteriorly, so that it would not be until the third stage of the thoracoplasty that effective compression would begin to be exerted. Meanwhile, even with the aspiration of air, the hazards of a persistent air pocket would be present, such as pressure effects and empyema. The cavity is thick walled and close to the spine, and the surrounding lung is dense,

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so that it is far from certain that even the most extensive thoracoplasty would close the cavity in this position.

The second choice would be to discontinue pneumothorax and to do a thoracoplasty after reexpansion. It is doubtful whether such

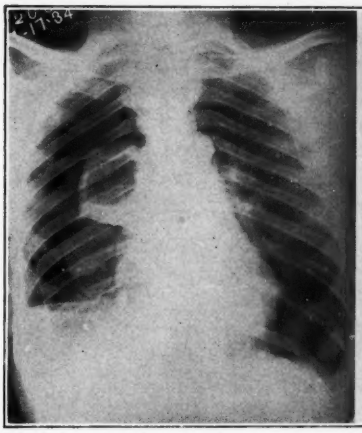

Fig. 1.—Case 1.

Fig. 2.—Showing spread during reexpansion.

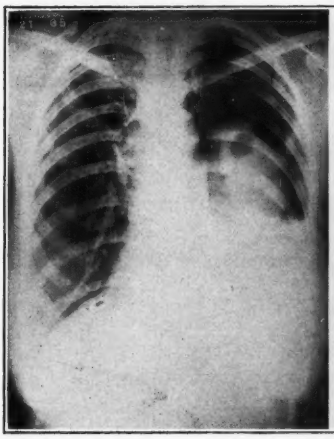

Fig. 3.—Case 2.

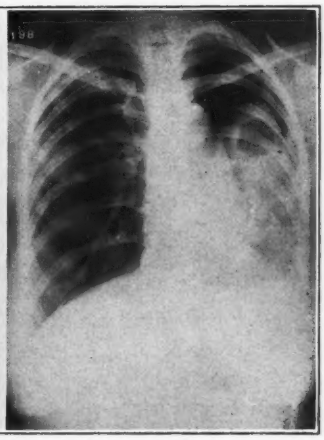

Fig. 4.—Showing spread during reexpansion.

a consolidated lobe would reexpand. If it did, it would be a very slow process. In our experience with an open cavity, the danger of spread during this time is very great. After discontinuing pneumothorax, most of these patients have an increase of activity with fever and increased sputum.

In Case 1, a pleural effusion developed and pneumothorax was discontinued to allow reexpansion and thoracoplasty (Fig. 2). Within a few months there was little reexpansion, but there was a spread to the other lung and the cavity remained open.

In Case 2 there was a large cavity in a consolidated left upper lobe (Fig. 3). Under pneumothorax the lobe shelled out. The cavity, however, became larger and a pleural effusion developed (Fig. 4). It was decided to discontinue pneumothorax and to allow reexpansion before doing a thoracoplasty. During this period the cavity grew larger, and the other lung became involved.

The third possibility is to do a lobectomy. The dangers of this procedure have been discussed.

A primary thoracoplasty without trial of pneumothorax would avoid these difficulties. Many of these cases, however, do not show the picture of a consolidated lobe with a large cavity until after pneumothorax has been started.

The following case in which lobectomy was done is reported, not as an example of the success of this operation because the result is not encouraging. It is hoped to elicit some discussion as to the proper method of procedure in these cases.

Case 3, V. M., a girl aged fifteen years, was admitted to the sanatorium, Nov. 13, 1933. For one year the patient had had cough and expectoration. There was a slight loss of weight and weakness. Three months before admission she had an hemoptysis of four ounces, followed by frequent blood streaking.

The patient was poorly nourished. Physical examination revealed signs of infiltration at the right upper lobe. The remainder of the examination was negative except for definite signs of mental retardation; she was only in the fifth grade at the age of fifteen years.

Daily sputum was 4 c.c. in volume, mucopurulent, and positive for tubercle bacilli. The roentgenogram showed diffuse infiltration in the right upper lobe, with a questionable small cavity. Under bed rest there was no improvement, and the x-ray picture on December 20, showed that the cavity was definitely larger. Pneumothorax was started on December 26. The upper lobe shelled out with the exception of the medial upper portion. The cavity became larger and the infiltration denser.

On April 26, 1934, a thoracoscopy was done. There was a large fold adhesion extending from the upper medial portion of the upper lobe to the posterior superior aspect of the chest wall. The anterior edge of this adhesion was cauterized, but the lung margin could not be clearly defined beyond this so that the cauterization was not completed.

There was no definite change after this procedure either in the general condition or in the sputum volume. Serial roentgenograms

showed that the cavity was increasing slightly in size. The sputum volume also increased. There was occasional exacerbation of symptoms with fever as high as 38.5° C. An attempt was made to dis-

Fig. 5. Fig. 6.

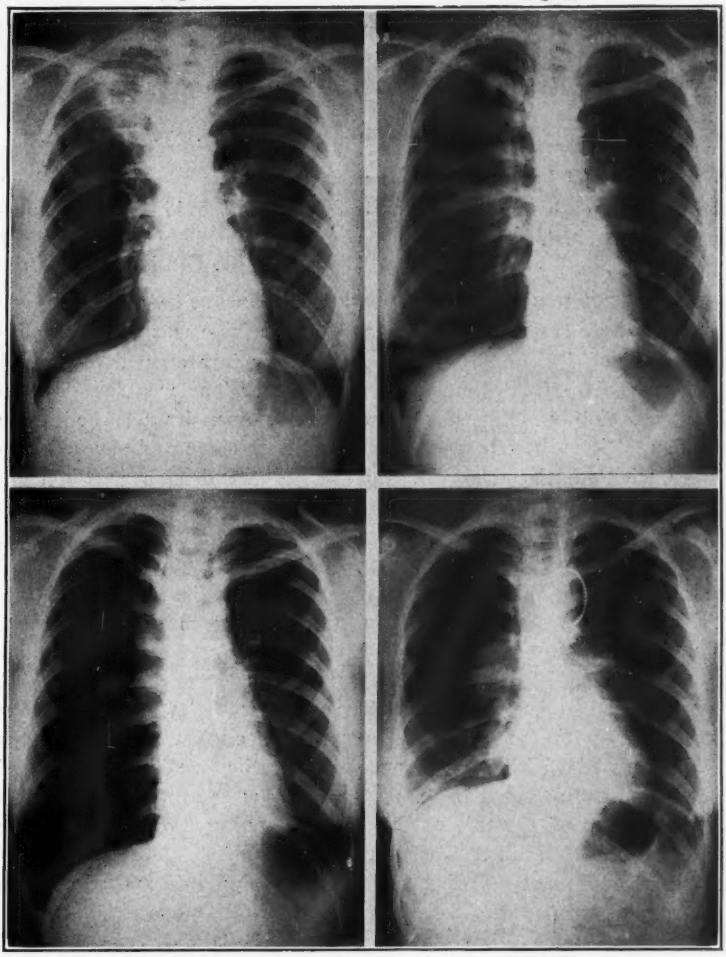

Fig. 7. Fig. 8.

Fig. 5.—Case 3. On admission.
Fig. 6.—After pneumothorax was started.
Fig. 7.—Before pneumonolysis.
Fig. 8.—Before lobectomy.

continue pneumothorax, but there was prompt increase in sputum and fever. The patient complained of considerable pain.

The patient was presented at several conferences of the chest clinic, and it was finally decided that this might be a proper case for

lobectomy. A summary of her condition at this time showed a loss of weight of nine pounds in six months, low grade fever as high as 37.5° C., sputum volume of 24 gm., red blood count of 4,600,000, and vital capacity of 80 per cent. The roentgenogram showed a collapsed, consolidated right upper lobe containing a cavity 2.5 × 3.5 cm. (Figs. 5-8).

Two weeks before lobectomy a right permanent phrenicectomy was done.

One-Stage Lobectomy (November 3, 1934).—Eighty-five mg. of avertin per kilo of body weight were administered per rectum, and an intratracheal catheter was introduced. Nitrous oxide oxygen anesthesia was started. An incision was made over the third intercostal interspace running from the paravertebral line to the anterior axillary line. This was extended through subcutaneous tissue and underlying muscle to the intercostal space. The incision was extended into the pleural cavity, and the pleural cavity widely opened along the superior border of the fourth rib. The upper lobe was found to be almost completely collapsed and held at the apex by a rather dense adhesion. The adhesion was clamped on both sides and severed, following which both ends were ligated. The adhesion was not on tension and evidently had no part in holding the cavity open. The adhesions between the upper lobe and the middle lobe were dissected, freeing the upper lobe. A Bethune tourniquet was placed around the base of the pedicle of the lobe and one around the lobe more distal to this. The lobe was resected by cutting between these two tourniquets. The stump was sutured with two layers of continuous chromic catgut. The stump was covered with the middle lobe which was pulled up and sutured over it. A stab wound was made in the ninth space in the posterior axillary line through which a catheter was introduced. This was led up alongside the two lower lobes and placed in the upper part of chest. The ribs were approximated with double sutures of chromic catgut No. 3 running from the superior border of the third rib to the inferior border of the fourth rib. The muscles were approximated with continuous and interrupted sutures of chromic catgut No. 2. The subcutaneous tissue and skin were approximated with silkworm gut. A firm dressing was applied. Closed drainage was established. The patient received 500 c.c. of whole blood following the operation.

Pathologic Report.—Specimen consists of a lobe of a lung measuring 7.5 × 5.5 × 2.5 cm. (Fig. 9). It is roughly pyramidal in shape. The pleura is complete with the exception of the base where the lobe had been removed from the lung. The pleura is thickened and appears as if there may have been an adhesion to the chest wall at the apex, and at this point the pleura rises for about 5 mm. in a rather broad band.

The incision by the surgeon opens into a cavity which is directly below the apex of the lobe and takes in the larger portion of this area. It measures 2 cm. by about 2 cm. It is roughly circular and rather sharply delimited, although a definite fibrous wall can be seen with difficulty. The cavity is lined by a pyogenic membrane which appears caseous. Small conglomerate, caseous masses, which measure less than 5 mm., are seen caudal to the cavity, and the most caudal tip

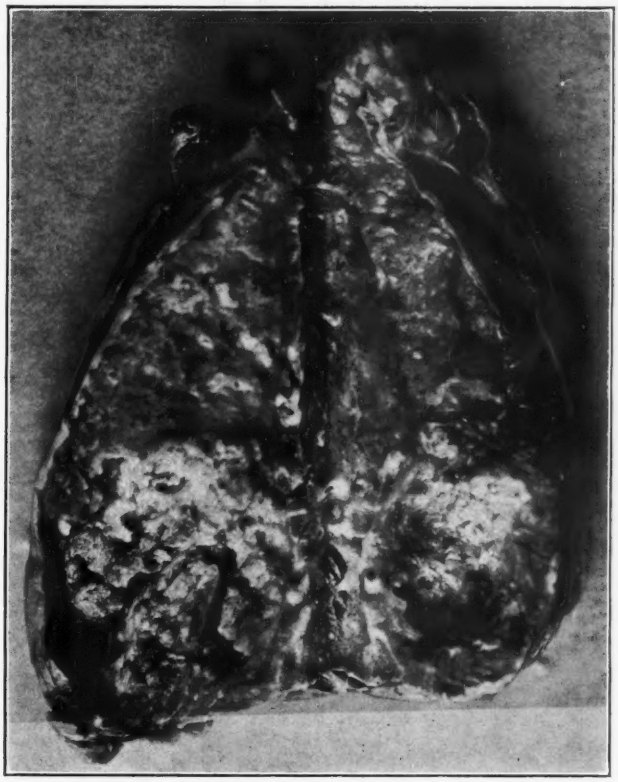

Fig. 9.—Lobe which was removed.

of the entire lung shows conglomerate, caseous masses which measure about 1 cm. These conglomerate masses lie directly at the line of incision from the lung at the hilus. Section made through the lung lateral to the cavity reveals the presence of a small amount of purulent material. The rest of the lung still contains some air, and in this air-bearing tissue small nodules, quite discrete, gray black in color and measuring less than 1 mm. are seen.

The immediate postoperative reaction was not severe. The patient ran a temperature as high as 39.5° C. for eight days; the pulse remained of good volume; and there was a moderate amount of serosanguineous drainage from the tube. The fever, however, persisted, and the drainage became definitely purulent. The injection of gentian violet through the tube proved the presence of a bronchial fistula three weeks after the operation. This fistula, however, gradually closed. The sputum has diminished in amount and has remained negative for tubercle bacilli throughout. The patient has continued to run fever until the present time, seven months after the operation. She has lost considerable weight, her appetite and general condition have gradually become worse in spite of many blood transfusions.

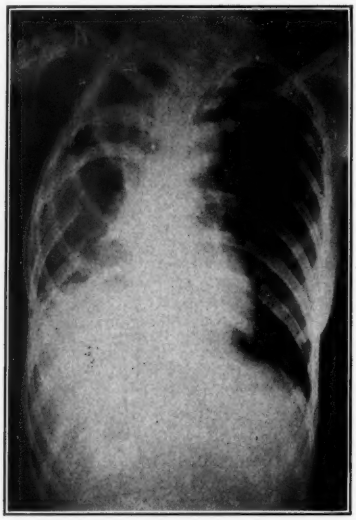

Fig. 10.—Case 3. After lobectomy.

There is a definite apical empyema which many roentgenograms show to be adequately drained. At one time she complained of severe headache and some stiffness of the neck. Meningitis was suspected, but lumbar puncture did not confirm this. She has never been in good enough condition to warrant exploration for residual pockets of suppuration or further compressive procedures (Fig. 10).

SUMMARY

This report deals with the problem of the proper method of procedure in cases in which there is a persistent large cavity in a consolidated upper lobe which is free and drops down to the region of the hilus after artificial pneumothorax. The objections are given to

thoracoplasty with the lung in this position, to thoracoplasty after reexpansion, and to lobectomy. It is suggested that lobectomy might be considered a logical procedure in this situation. A case in which this was done is reported.

The patient became free from tuberculous sputum but developed an apical empyema from which she is still suffering. There was no permanent bronchial fistula.

DISCUSSION

DR. LEO ELOESSER.—I think Dr. Freedlander deserves great commendation for having had the courage to come out and show us new paths. I suspect that some of us have done what he has done, but have not had the courage to say so. The same indications have presented themselves, and I have done one lobectomy under circumstances such as he did, against the protest of my confreres. This woman was syphilitic, had an aortitis and an ankylosed hip; after some months she finally succumbed to tuberculous pleurisy.

I think one may find some difficulties, as Dr. Freedlander says, in dealing with the hilum. I believe, however, if the hilum is purely tuberculous tissue, not secondarily infected, that the difficulties may not be so great as we might think, for such tissue is not so much to be feared.

I have done a lobectomy, not primarily for pulmonary tuberculosis but for bronchiectasis that followed upon partial thoracoplasty for tuberculosis. The lower bronchiectatic lobe was nontuberculous. This patient recovered and the lobectomy wound healed, although a sinus has persisted.

DR. POL N. CORYLLOS.—I want to congratulate Dr. Freedlander for his attempt. This question has been hanging in the air for some time, and it is fortunate that one of us has brought here a case of lobectomy for huge tuberculous cavity. We all admit that there are huge cavities formed by almost an entire lobe which has been shelled out. Often these cavities cannot be collapsed and remain definitely closed by any of the procedures at our command because of the resistance of their walls and the large diameter of their bronchus. Should we abandon these patients as beyond any surgical help?

I see but two ways to approach this problem: one is lobectomy; the other is pneumonostomy of the cavity to the chest wall after the creation of solid pleural adhesions, if such do not exist before pneumonostomy, and attempt to obliterate the draining bronchi by direct action of chemical substances or muscular flap upon their openings into the cavity. I am not yet ready to use lobectomy because of the danger of mixed infection tuberculous empyema. But I have been trying the second procedure after I had failed to close the draining bronchi by injection of chemicals into the cavity. My results do not warrant, at the present time, any definite conclusions. I shall report them later.

DR. E. J. O'BRIEN.—I should like to report my experience with lobectomy for pulmonary tuberculosis. I had a case with a small, round, thick-walled cavity behind the heart, in the lower lobe on the left side, with a perfectly clear upper lobe. The right side was also clear. Pneumothorax was impossible because of adhesions, and a phrenic nerve operation failed to close the cavity. Rather than do a complete thoracoplasty which would be necessary, the left lower lobe was removed in the hope of preserving the function of the upper lobe. The patient had an uneventful convalescence until the seventh day when pneumonia developed in the right side, and the temperature rose

to 105°. The patient died on the eighth day. Postmortem examination showed the operated side clear, the upper lobe fully expanded, no fluid, the stump all right, but the opposite side was one solid mass of tuberculosis.

I mention this because I am afraid in the manipulation of a tuberculous lobe, which can hardly be avoided, there is great danger of spread. I think, in the future, I should be awfully afraid of taking out a tuberculous lobe or manipulating it in that manner.

DR. H. L. BEYE.—I wish to report the case records of two patients in connection with the paper which Dr. Freedlander has presented. The first patient, a woman thirty-nine years of age, was suffering from what we thought was a nonspecific sacular bronchiectatic involvement of the right lower lobe. The rest of the lung and the opposite side showed no evidence of disease. Sputum examinations were negative for tubercle bacilli. A two-stage lobectomy was carried out without incident. The lobe presented a striking pathologic picture of tuberculosis with large saccular bronchiectatic cavities and caseation of the parenchyma. Tubercle bacilli in large numbers were readily demonstrable in the caseous material in the bronchiectatic cavities and in sections of the tissue. The operation was performed in November, 1934; recovery was smooth. She is convalescing in the state tuberculosis sanatorium and has gained about thirty pounds in weight. A small bronchial communication is still present. It would seem as though she will go on to a complete arrest of the disease.

The second patient, a woman aged forty-five years, is one in whom pneumonectomy was performed for known pulmonary tuberculosis. This patient had phrenic exeresis followed by complete paravertebral thoracoplasty performed in 1929 in the University Hospital, at which time there was a large cavity in the left upper lobe and infiltrative disease of the lower. Following thoracoplasty the cavity was not completely closed, and in 1930 an axillary attack was made with the removal of the anterior segments of seven of the upper ribs. Improvement in a general way was striking following the operative treatment, but a cavity has persisted in the compressed upper lobe, and the sputum has been persistently positive for tubercle bacilli. She is a school-teacher and very eager to get back to her work. Bronchography aided in visualizing a long ovoid cavity situated in the long, narrow, upper lobe and lying in a space surrounded by a heavy bony framework. The latter consisted of the transverse processes of several vertebrae and massive regenerated bone from resected ribs. Reoperation was performed posteriorly with the idea of removing the regenerated bone to obtain further compression. The degree of collapse which was found was so great as to make it unlikely that further removal of regenerated rib and transverse processes would be successful in obliterating the cavity in the upper lobe. The procedure itself would be extremely difficult technically, as well as unlikely of satisfactory accomplishment.

Pneumonectomy was decided upon and carried out without a great deal of difficulty. The pleural space was completely obliterated, and the lung could be readily mobilized except in the region of the apex of the upper lobe. Here the adhesions were very tough. The hilus was ligated by mass ligature of No. 4 chromic gut and division was made distal to the ligature by cautery knife, using the high frequency current. The hilar stump was coagulated with the high frequency coagulating current to form a heavy eschar. The stump of the bronchus was closed by a transfixion ligature.

The upper lobe contained a large abscess containing caseous material and frank pus surrounded by markedly fibrotic parenchyma and many small bronchiectatic cavities and dilated bronchioles. On the surface of the lower lobe were many circumscribed tubercles. The parenchyma presented the evidence of an old and, for

the most part, healed tuberculous process. There was no bronchiectasis. Smears from the caseous areas and from the isolated tubercles demonstrated the tubercle bacilli in large numbers.

The operation was performed April 10, 1935, under nitrous oxide anesthesia. The postoperative course was smooth, and her convalescence has been very satisfactory in the state tuberculosis sanatorium. There is no residual rest cavity present, but a bronchial sinus through the chest wall still persists. Her general condition is excellent.

MR. J. E. H. ROBERTS.—I have never knowingly removed a tuberculous lobe, but of the 100 cases of lobectomy and pneumonectomy which my colleagues and I have had at the Brompton Hospital for bronchiectasis [with a total early and late mortality of 15 per cent], three patients have subsequently died of tuberculosis—two of the cases have been published by my colleague, Tudor Edwards; the third case is that of a child in whom I recently removed the left lower lobe for nontuberculous bronchiectasis, and in which no evidence of tuberculosis has since been found histologically—within three months the child died of tuberculous meningitis and general miliary tuberculosis. That child, like nearly all children who have lobectomy for bronchiectasis, had enlarged glands in the hilum, and it occurs to me that the crushing of these glands, which possibly contained tubercle, during the course of the operation is the cause of the subsequent dissemination.

I have a case from another series of lobectomies done for growth. I removed the left lower lobe from a young woman in 1932, and she remained well for three years. A small number of histologic tubercles were demonstrated around the growth when the lobe was subsequently examined. She has now returned to the hospital for frank pulmonary tuberculosis.

I feel that if we are getting deaths from generalized tuberculosis when we remove lobes in which the tuberculous disease is so small in amount that we do not recognize it, the risk must be very much greater when there is a frank tuberculous disease in the lobe. I believe it is going to prove, if it is generally attempted, to be an operation with a high mortality, and that it is well to remember the old surgical maxim, that the remedy we propose should not be more dangerous than the disease for which we propose it.

DR. E. W. PHILLIPS.—I should like to suggest a somewhat different procedure for use in large apical cavities; that is lung destruction by Graham's method of cautery pneumectomy which Yates mentioned several years ago. This, of course, is applicable only where the cavity is adherent to the chest wall.

In 1929 I had a patient with a large apical cavity, possibly the size of a large orange, upon whom I did an apicolysis and used a gauze pack in the extrapleural space. Upon removal of the gauze, it was found that ulceration through into the cavity had taken place. Feeling that this complication would interfere with cavity obliteration, I destroyed the apex of the lung with the actual cautery, leaving as the top of the lung the base of the cavity. I was very much worried about the many bronchial fistulas, fearing that they would prevent healing. Complete healing, however, took place within three months. This man today is working and free from evidences of activity. I simply mention this as a method of treating these large apical cavities that thoracoplasty alone may not obliterate.

DR. JOHN ALEXANDER.—The removal of a nontuberculous upper lobe, whether by the one-stage or by two-stage technic, has been reported as almost constantly resulting in a bronchopleurocutaneous fistula, and an empyema. The division of a tuberculous upper lobe hilum would almost surely be complicated by a mixed tuberculous and pyogenic empyema with a bronchial fistula. In view of the fact that the modern thoracoplasty operation closes such a large percentage of pulmonary cavities

(even huge ones), I believe that Dr. Freedlander would scarcely undertake a lobectomy in preference to a thoracoplasty if the same patient should first present herself to him today. I doubt whether lobectomy or pneumonectomy will ever be widely accepted for uncomplicated cavernous tuberculosis.

Dr. Freedlander seems to have had exceptionally bad luck with regard to the spread of tuberculosis in the contralateral lung while he has been permitting the expansion of a lung which he intended to collapse by thoracoplasty. I have frequently permitted a pneumothorax lung to expand completely or almost completely as an important preliminary to a thoracoplasty, and I do not recall any more troublesome symptoms than occasional increase in cough and expectoration and, rarely, a little fever; the cavity may, of course, enlarge as the partially collapsed lung becomes expanded. I suspect that those patients who develop dangerous signs and symptoms during the expansion of the pneumothorax lung had lesions that were predominantly exudative in character.

DR. S. O. FREEDLANDER.—I am grateful for the discussion, which was the chief purpose in presenting this paper. I myself am far from convinced that lobectomy is the answer in this type of case. One of the discussors, however, missed one of the points of this paper. That is, that one of the chief difficulties is that the lobe is free and does drop down. Of course, if it is anchored to the chest wall, thoracoplasty would be the proper procedure, but the point is that the lobe is free and drops down, so that we must do a thoracoplasty either in that position or after reexpansion. The dangers which we have encountered in reexpansion complicate the problem.

REPORT OF A CASE OF ESOPHAGOGASTROSTOMY FOR CARCINOMA OF THE ESOPHAGUS

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THE surgical treatment of carcinoma of the esophagus has not met with the success that the ingenious, painstaking efforts of thoracic surgeons the world over have earned or justified. Reasons for failure with surgery are apparent. Ninety per cent of carcinoma of the esophagus develops after the age of fifty years, so that for the most part it is a disease of advanced years. In this period cardiorenalvascular changes and lack of vitality increase the operative hazards. Again, the diagnosis is not usually established in an early stage, and the patients come to the surgeon in a state of inanition that often borders on chachexia. The operation itself is of considerable magnitude, and time consuming, owing to the relative inaccessibility of the esophagus and the vital anatomic relationships. Technical difficulties, particularly in the handling of the proximal esophageal stump, are presented, which, while not insuperable, are often responsible for fatal complications of shock, infection, and hemorrhage. Recurrence is responsible for ultimate death of a number who have survived the operation.

In the cervical region, where the operative field is accessible, there has been an operative mortality of 20 per cent. Of 114 patients in which Glück radically removed the trachea and larynx as well as the esophagus, 8 were alive and well after five years. After a less radical procedure in a series of 82 cases collected by Lotheissen in 1929, only one was living and free from recurrence five years after the operation, although 10 were living for shorter periods. Garré reported one alive after twelve years, and Turner, one for ten years.

In malignancy of the abdominal part of the esophagus including cases in which the cardia was involved, there have been reported 5 operative successes by the abdominal route (Bircher, Kumell, Kuttner, Voelker, and Brun), and 2 by a combined abdominal and thoracic operation (Zaaijer and Hedblom). Apparently none of these patients lived longer than a year, although Hedblom's patient died an accidental death.

Removal of the thoracic esophagus has been even less successful. With numerous attempts, there have been a number of short-lived operative recoveries, but of these only 4 patients lived longer than a

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year (Torek, Eggers, Lilienthal and Turner). It is with some hesitation and regret that I report in this paper another failure, though there may be something of interest in the method of esophagogastrostomy utilized.

Many operations have been devised for the resection of the thoracic esophagus. Some have been successful, experimentally in dogs, but have failed when put to test in the human being with actual malignancy. It is essential in the human being to remove the tumor widely to minimize recurrence. This practically bars an end-to-end anastomosis of the esophagus, because the large defect cannot be closed without tension. When it has been possible to approximate the ends, union has not taken place without leakage, whether the anastomosis has been attempted by suture, or Murphy's button (Sauerbruch) or over a bobbin (Bengolea). Saint believed that the danger in an end-to-end anastomosis was constriction of the blood vessels with resultant necrosis; so he used interrupted mattress silk sutures inverting 2 cm. of the esophageal wall, and was careful to avoid the submucosa, where the vessels ramify, in a superimposed, continuous inverting suture. He had considerable success with end-to-end anastomosis in dogs, but he did not put the technic to test in the human being.

Operations of practical value that have evolved from the mass and maze of experimentation and trial are of four general types.

1. Extrapleural esophagoplasty, as devised by Lilienthal, and worked out independently on the cadaver by Höfer and Kofler, utilizes a skin flap to restore the canal.

2. Tunneling. This is an operation carried out through abdominal and cervical incisions without opening the thoracic cavity. The esophagus is freed bluntly by the fingers its whole thoracic extent.

3. The Torek operation. A transthoracic resection, either transpleural or extrapleural, followed by a transplantation of the proximal stump to the upper chest wall.

4. Esophagogastrostomy.

In all these methods, a preliminary gastrostomy usually is done several weeks before the radical extirpation.

The first type of operation, *extrapleural esophagoplasty*, proved successful in one instance in Lilienthal's hands. This particular patient lived sixteen months after operation, but died of pneumonia incident to perforation of the bronchus following cauterization of a small local recurrence at the site of anastomosis. There was a definite tendency in this case for a recurring stenosis at the junction of the esophageal wall and skin tube. Archibald tried this operation once, but the skin flap became gangrenous and the patient died of sepsis. Neuhof experimentally found it feasible to establish a connected granulation tract about a rubber tube, which subsequently became

epithelialized. Duff Allen had some experimental success in establishing the continuity of the organ by the use of a double cuff of fascia lata.

In *tunneling,* one of three plans is followed when the esophagus has been freed.

(a) After division of the esophagus intraabdominally and closure of the gastric end, the viscus is pulled through the cervical wound, the growth is resected, and the stump is implanted as in the Torek operation. Turner used this method and had one operative success and two failures. One patient died of hemorrhage and the other of sepsis following laceration of the tumor during its removal.

(b) When the tumor is low, the esophagus is pulled down through the hiatus, and the resection of the growth is performed intraabdominally. The stomach is then transposed to a subcutaneous position for later plastic anastomosis with the antethoracic stump. Gorbrant reported 6 cases, with one operative success. This patient lived six months, and died of an intercurrent disease. Two cases proved to be inoperable; the other three patients died, one of pneumonia the third day, the second because of perforation of the tumor while being loosened, and the third from a phlegmon of the antethoracic site of anastomosis of the stomach and the esophagus.

(c) In the third variation for growths placed at high levels as carried out by Kumell, the stomach is mobilized and pulled through to the cervical wound, the tumor is then resected and an extrathoracic esophagogastrostomy performed. In 5 operations upon dogs and 2 upon human beings, there was no operative recovery; hemothorax and ruptured pleura were specified as the causes of death.

It would seem that this tunneling operation is a blind and unsafe procedure. It is impossible to determine accurately the extent and relations of the growth. There is great probability of uncontrollable hemorrhage, injury to the pleura, and tearing into the growth.

Torek Method.—The technic of this operation is so well known from the writings of Torek and Eggers that it does not need discussion here. Torek has had at least two operative recoveries, and one of these, the outstanding case of all esophageal surgery, remained perfectly well for a period of thirteen years, to die at the age of 79 from pneumonia. Eggers has had likewise two operative successes. Both of his patients died ultimately of recurrence. In March, 1934, Eggers performed the operation successfully for a case that proved to have chronic stenosing, nonmalignant ulceration just above the diaphragm. He is now constructing a skin tube from the chest wall for this man.

Primary Esophagogastrostomy has been the most popular type of operation, particularly for growths at the lower end of the esophagus, and also those which have involved at the same time the cardiac end

of the stomach. Probably this is because it establishes continuity of the esophageal tract at the first operation and avoids a secondary subsequent esophagoplasty, which in itself has a mortality of 20 per cent. Three main types of operation have evolved, depending upon the method of approach: (a) abdominal, (b) abdominal thoracic, (c) transthoracic.

(a) For low growths, intraabdominal resection and anastomosis take advantage of the defensive qualities of the peritoneum; seek to avoid pulmonary collapse and to save mediastinal contamination. By this method, Ach reported 4 failures in 4 cases; Zaaijer, 3 operative successes in 7 operations; Voelker, 1 in 3 operations; Bircher, 1 in 2 operations. Bircher's patient was reported well eighteen months later.

To take the anastomosis out of the thoracic cavity, Levy, and also Heuer, Andrus and Bell suggested that in low growths the diaphragm be transplanted to a higher level in the thorax. At a second stage they did the resection. For the anastomosis, Heuer utilized the Halstead bulk-head suture which had proved most successful in the experimental work of R. T. Miller and Andrus. Heuer's one patient died after the first stage operation from gangrene of the esophagus and an infection in the pleural cavity. He felt it had been a mistake to remove the esophagus from its bed in the first stage.

(b) *Abdominal Thoracic Approach.* Zaaijer and also William Levy performed a preliminary thoracoplasty to bring the esophagus near the chest wall. Then, through a combined abdominal and thoracic incision, split the diaphragm to the hiatus; the stomach was divided below the tumor; closed, returned to the abdomen, and the diaphragm sutured. Next, the esophagus and the tumor were brought out on the chest wall, and the pleural cavity was closed behind them. The tumor was removed a few days later. In Zaaijer's one reported case the patient left the hospital fourteen days after the operation, taking food through a tube connecting the gastrostomy and the esophageal stoma. Hedblom removed a growth involving the esophagus and cardia also successfully by this method, but his patient committed suicide a short time later. In a variation of this technic Kirschner transferred the stomach from the abdominal cavity to a subcutaneous position on the chest wall for later anastomosis with the esophageal stump brought out through the neck to antethoracic position. In two reported cases the patients died, one, twenty-four hours and one five days after operation.

(c) *Transthoracic Approach.*—With either transpleural or retropleural exposure, the diaphragm is opened and the stomach displaced into the thorax to a degree sufficient to bridge the esophageal gap. In 1925 Herman Fischer described a method of anastomosis before

this Association, which on the basis of his experimental work on the cadaver, gave promise of success. I can find no record of trial by any other surgeon, although Starr of Toronto reported to Fischer that he secured a perfect anastomosis by a similar technic, demonstrated at autopsy after the patient had died of a pulmonary embolism on the fifth day.

It was this operation which I performed in the case herewith reported. Briefly, it involves transpleural exposure and mobilization of the tumor; phrenicectomy to immobilize and relax the diaphragm; transposition of the stomach through the diaphragm into the pleural

Fig. 1.—X-ray appearance of carcinoma of thoracic esophagus in Case A. K.

cavity. The anastomosis is carried out somewhat after the principles of the experimental method of Willy Meyer, published in 1909, in which the ligated oral end of the esophagus is introduced into the lumen of the fundus of the stomach, through a small opening in the stomach wall. By Fischer's technic, a quadrilateral flap of the stomach wall including only the serous and muscular layers is reflected downward, and the wall of the esophagus is sutured to the submucosa. The seromuscular flap is sutured around the esophagus, and this anastomosis is buried by a Lembert suture. In due time the plain catgut ligature on the esophageal stump is digested and patency is established.

CASE REPORT

History.—A. K., aged forty-eight years, carpenter, married. Admitted to Presbyterian Hospital April 21, 1932. Chief complaint, dysphagia first manifested three months before admission. At the first bite or two of food, there was pain in the pharynx. After an intermission of several weeks, there was pain in the epigastrium, continuous, dull, not influenced by the taking of food, without nausea or vomiting. This continued for a week. Three weeks before admission, pain, brought on by swallowing, returned to his throat. He could eat only small quantities of food. Experienced a sensation of something letting go in his throat, after which

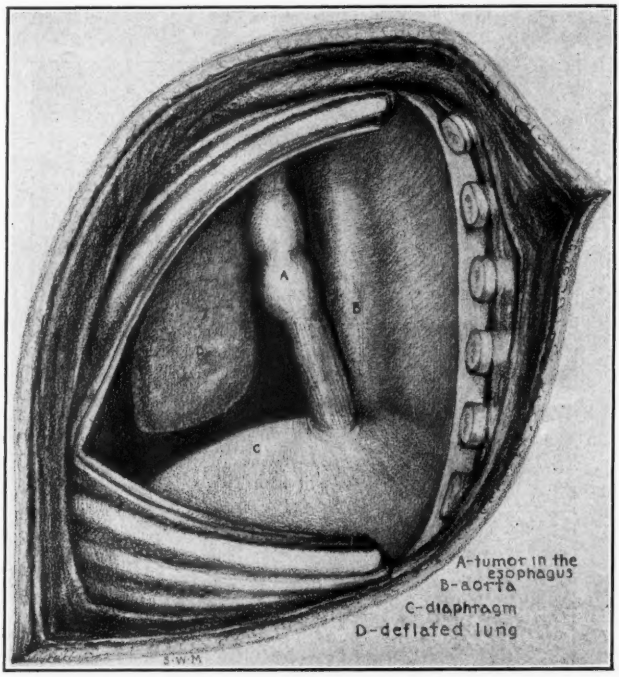

Fig. 2.—Carcinoma of esophagus lower third. Tumor 6 cm. × 3 cm.

food seemed to pass down more easily. Occasional regurgitation of food and water. One day before admission he was unable to swallow either food or fluid.

Past health excellent. No previous accidents or operations. Family history negative. Married for twenty-five years. Four children living and well. Had been a heavy drinker of coffee. Very little alcohol. Smoked tobacco in a pipe (one-third package a day).

Physical Examination.—A well-developed, rather wiry type; weight 139 pounds. This is 20 pounds less than average weight. A few carious teeth, and moderate pyorrhea alveolaris. Heart, action regular, good force, and 64 to the minute. No valvular disease. Blood pressure 100/54 mm. Abdomen normal, except for slight tenderness in the epigastrium on deep pressure. Lymph nodes palpable only in the inguinal region. *X-ray examination* by Dr. Grier showed complete obstruction

in the esophagus about 2 inches above the diaphragm and great dilatation above this point. *Urinalysis* normal. *Blood examination,* R.B.C. 4,500,000; hemoglobin 80 per cent; W.B.C. 7,800; polymorphonuclears 78 per cent; small monocytes 21 per cent; myelocytes 1 per cent; Wassermann and Kahn reactions were negative.

On April 22 Dr. Ellen J. Patterson performed an esophagoscopy. There was a rather soft growth filling the lumen of the esophagus 37 cm. from the teeth, chiefly on the right wall, which bled easily on being touched. Specimen was removed for pathologic examination. A bougie was passed through the cardia. The patient could swallow fluids readily after this. *Pathologic report:* Typical epidermoid carcinoma of the squamous acanthotic variety. After consultation with Dr. Patterson and Dr. Orr, the family physician, surgery was decided upon. On May 2, 1932, a

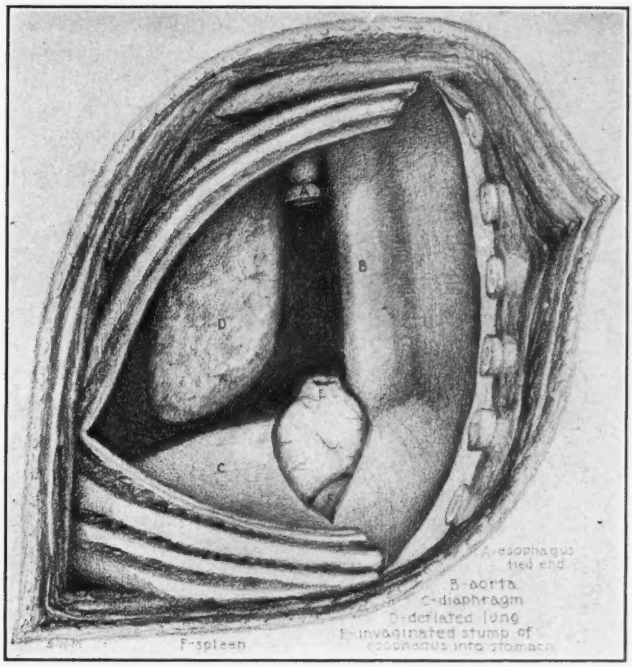

Fig. 3.—Tumor resected. Proximal end ligated with plain catgut. Distal end ligated and turned into the stomach. Diaphragm split.

Senn gastrostomy was performed, somewhat near the pylorus. There was no evidence of malignancy in the abdominal cavity. In the course of further hospital observation there was no contraindication found for radical operation.

Operation: On May 26 an esophagogastrostomy was performed by the technic of Fischer. The patient was placed on his right side with the arm overhead. Under 0.5 per cent novocaine anesthesia the seventh intercostal space was opened from the costochondral junctions anteriorly to behind the angles of the ribs. Then nitrous oxide and ether were administered. The pleura was opened and exploration carried out. The exposure for exploration was adequate, but not for operative procedure, so the seventh, sixth, and fifth ribs were divided posterior to the angles, and later to give better access to the lower part of the field, the eighth and ninth ribs likewise. Hemostasis was effected. There was little difficulty in stopping bleeding

from the intercostal vessels. The lung was nearly totally collapsed at this stage, but was reexpanded from time to time as the operation proceeded. The ligamentum pulmonis latum was divided. The esophagus was then freed, beginning at a point above the tumor, the lower end of which was 10 cm. above the diaphragm. The tumor was 6 cm. long, 3 cm. wide, and nonadherent. Tape was placed under for traction purposes. The vagus nerves were identified and freed from the esophagus. The thoracic duct was not identified. Two vessels running from the aorta to the esophagus were ligated. Dissection was carried out, largely with the finger downward until the hiatus was reached. The diaphragm was then split for a distance of 8 cm. This allowed the stomach to be brought up into the chest. It was found

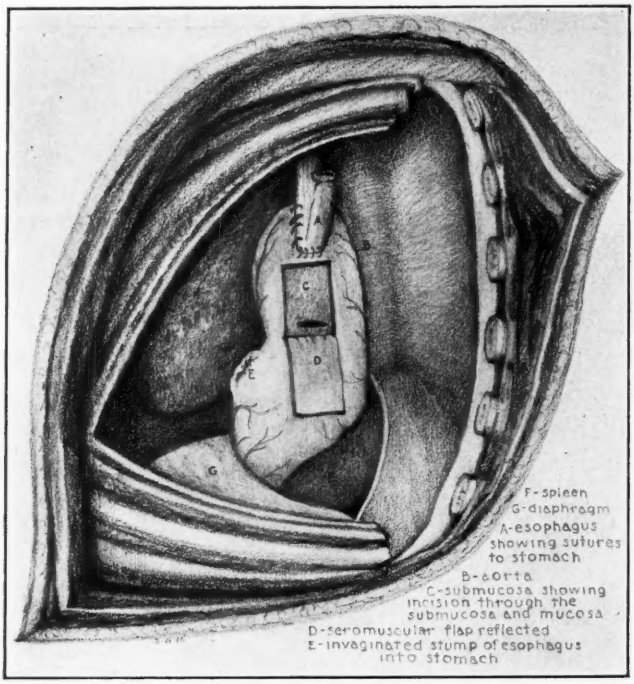

Fig. 4.—Stomach pulled into pleural cavity. Seromuscular flap reflected. Esophagus and stomach sutured above.

that the fundus of the stomach could be secured to a point several inches above the level of the tumor. It was thought, therefore, that it was feasible to do an anastomosis between the stomach and the esophagus above the level of the tumor. The esophagus was divided between Payr's clamps 2.5 cm. below the tumor through apparently healthy tissue with an endothermic knife. The upper end was protected by a pad. The distal end was ligated with heavy catgut. A purse-string of linen had previously been placed around the esophagus close to the cardiac orifice. The stump was turned into the lumen of the esophagus and the purse-string tied over it. Several interrupted sutures were taken to reenforce the purse-string. The tumor was then removed, the line of section being taken 2.5 cm. above the growth through apparently healthy tissue and the proximal end ligated by heavy, plain catgut. In the process of separating the esophagus there was some adhesion of the organ

to the surrounding tissue. Section of this tissue was removed and examined microscopically by Dr. Wallhauser by the frozen section method. He reported fat and fibrous tissue. No evidence of malignancy. Anastomosis was then carried out according to the method of Fischer. A quadrilateral flap of the seromuscular coats 2.5 cm. by 2.5 cm. was reflected downward from the anterior wall of the fundus. It was found difficult to separate the serosa and muscularis from the mucosa because it seemed thin. The mucosa was opened in the process at one point, and this was enlarged for the esophageal stump. It was found that the esophageal stump was not long enough to stay inside the stomach lumen easily; so the catgut which had been utilized to ligate the esophagus was threaded on a needle and this was brought out through the anterior wall of the stomach, and the two ends were tied at a point

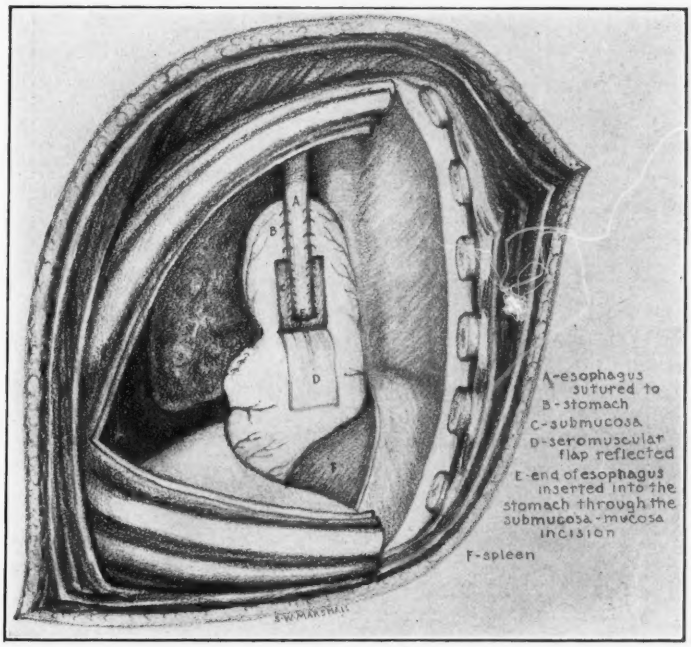

Fig. 5.—Esophagus stump inserted into gastric incision and secured by sutures.

3 cm. below the opening in the stomach wall; No. 1 chromic catgut suture was then taken circumferentially between the wall of the esophagus and the cut edge of the stomach wall. The serosal flap was then sutured in place. Upon this was superimposed a linen thread in an endeavor to bury the first line near the stomach. This was entirely successful anteriorly, but posteriorly did not seem entirely to bury the first line of stitches. This particular portion was in apposition to mediastinal tissue and extrapleural. The fundus of the stomach when the anastomosis was finished was 15 cm. above the level of the diaphragm. No gastric vessels had been divided, and in this way it seemed that the circulation of the anastomosis was enhanced. With the stomach there had been dragged into the pleural cavity some of the gastrohepatic omentum. The spleen was in the field, but was excluded from the pleural cavity when the rent in the diaphragm was closed. There had been little interference on account of diaphragmatic movement, so the severance of the phrenic nerve was re-

served until this time, about 2.5 cm. above the diaphragm through a small opening in the pericardial pleura. Plain catgut sutures were then placed to close the original opening in the pleura in the region of the aorta and costovertebral angle. In doing so, there was a spurt of blood which seemed to come from the aorta. Whether it was due to a needle prick, or a loosened, small, unligated vessel, was not determined. It was clamped, and secured with a stitch. There had been a slight oozing from the esophageal bed, but at the close of the operation the field seemed entirely dry. Closure of the chest wall was made by four through-and-through linen stitches looped around the seventh and eighth ribs, and the musculature in layers with No. 2 chromic catgut. Effort was made by the anesthetist to expand the lung, but this was incomplete. Just prior to the closure of the wall a drainage tube was inserted

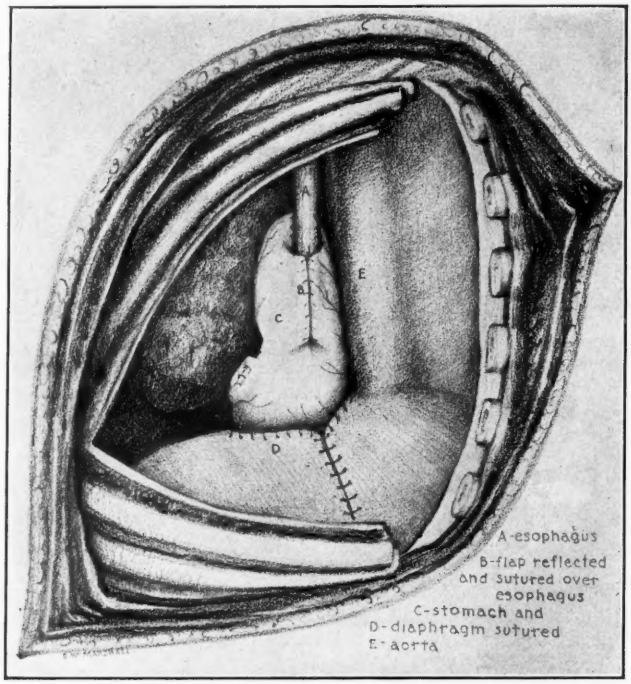

Fig. 6.—Flap sutured over esophagus and buried by Lembert sutures. Diaphragm closed. Stomach sutured to diaphragm.

through the ninth intercostal space in the posterior axillary line. The skin was closed with silkworm gut and dermal. The ribs came nicely into place. The chest wall closure seemed secure. Operating time was three hours.

Observations: The heart beat strongly throughout the operation, averaging 120. Irregularity developed several times, once when there was traction made on the vagus nerves and sometimes when pressure was exerted against the aorta. Blood pressure remained constantly 120/80 mm. The patient's color remained good throughout. There was no disturbance in respiration apparently at any time when the pleural cavity was opened, or even with the total collapse of the left lung. Diaphragmatic action was not exaggerated at any time. It ceased as soon as the phrenic nerve was divided. Stimulation by one ampule each of caffeine and ephedrine

and strychnine sulphate was given during the operation, more as a prophylactic measure than that there was any actual need of it. At the close of the operation a coffee enema was given. There seemed to be no need of blood transfusion, though I believe that this should wisely be a routine measure. Dressings were reenforced by elasticon support.

Postoperative Course: The patient's condition following operation continued satisfactory for twenty-four hours. Temperature remained normal. Pulse averaged 120, and was regular in force and frequency. Blood pressure was from 74/46 mm. to 74/64 mm. Respirations were 36 to 40, but were not especially labored. The skin tended to be cold continuously, and there was pallor. In the afternoon of the second day the picture changed for the worse with weakened cardiac action and dyspnea. Moisture developed in the right lung. Signs pointed to atelectasis of the left lung. The patient had been placed in an oxygen tent, and given appropriate stimulation. Death came apparently from circulatory failure, twenty-eight hours after operation. Drainage from the chest by catheter had been all told 400 c.c. of blood-tinged fluid.

Autopsy Findings: Thorax, left lung completely collapsed. Heart in approximately normal position. Right lung normally distended, with air. In the left pleural cavity about 5 inches of the stomach had been pulled up through the diaphragm and anastomosed with the esophagus. The stomach was sutured to the diaphragm. A ligature closed the esophageal lumen. There was no free blood in the pleural cavity. There was a small amount of plastic exudate in the lower portion. Lymph nodes at the hilus were considerably enlarged, and several of them were completely calcified. There was no evidence of malignancy in the lung or lymph nodes. There was moderate anthracosis. There was no evidence of tuberculosis. Heart was normal in shape and size. The pericardium contained about 30 c.c. of cloudy, reddish fluid. All valves of the heart were normal. Abdomen: The gastrostomy was attached by fibrous adhesions to the left edge of the liver. There was no wound infection, nor peritonitis. Spleen, adrenals and pancreas were normal. Kidneys were somewhat swollen and on section showed retraction of the capsule. This capsule stripped easily and disclosed smooth cortical surface. The vessels of the medulla and cortex were congested, and the glomeruli stood out fairly prominently. The pelvis was free and clear, as were the ureters. Liver was normal, except for the adhesions as above noted. The gallbladder was normal and contained no stones. The gastrointestinal tract was normal, except for the anastomosis of the esophagus with the stomach and the gastrostomy.

Microscopic examination of the left lung disclosed atelectasis with very numerous compound granule cells and congestion of the capillaries; of the kidney showed very marked dilatation of the capillaries; glomeruli congested with edema; of the heart suggestion of cloudy swelling.

As to the value of this method of esophagogastrostomy based upon this one case, unfortunately I can make no deduction, since death came in twenty-eight hours apparently from shock and pulmonary collapse. At the autopsy there was no gross evidence of infection of the pleura or mediastinum. The suture line was intact, and there was no hemorrhage. In the performance of this operation there was some difficulty in reflecting the seromuscular flap of the stomach, but the method seemed entirely practical. The presence of a gastrostomy did not interfere with transposing the stomach above the diaphragm.

Fischer has suggested the substituting of a jejunostomy to obviate this difficulty. I would be willing to repeat the operation in a similar case of supradiaphragmatic tumor, but for tumors lying in the mid-thorax and above this method is not suitable because it requires too long an oral stump and too great a displacement of the stomach to fulfill the requirements of an anastomosis which is safe against leakage and does not interfere with the circulation or function of the stomach.

The high mortality following these radical surgical operations, which has not decreased with the years, presents a real challenge to the thoracic surgeon and emphasizes the imperative need for careful study of the factors in failure with a hope of profiting thereby. In 1929 before the American Surgical Association Torek discussed fully the cases of mortality. Those having to do with infection of the pleura and mediastinum, necrosis of the esophageal stump, diaphragmatic hernia, hemorrhage, and pneumothorax are largely the result of technical errors, and, it would seem, should be amenable to reduction by perfection of technic born of experience. Deaths due to cardiovascular disturbances are not so easily preventable, even though by preliminary study heart efficiency may be properly evaluated. Apparently some patients are greatly shocked and others are not. The vagus nerve handling and division in the course of the operation is undoubtedly a factor, but not necessarily so. According to Eppinger and Hess those patients with heightened irritability of the autonomic nervous system are sensitive to vagus injury. This may be controlled by the administration of atropine and local injection of novocaine into the nerves. Heller has recommended regional blocking of the vagus plexus at the level of the hilum. He believes that any temporary paralysis is harmless.

Death as the result of undiscovered metastasis may be minimized by careful examination of the intraabdominal viscera during the course of the preliminary gastrostomy; death on account of any local recurrence may be minimized by wide removal of the malignant growth at the first operation. Unquestionably, mortality will be lowered by wise selection of subjects; avoiding those who are, from a general standpoint, poor surgical risks, those in whom there is a suspicion of metastasis. Nevertheless, in any case doubtful as to operability, we feel that it may be good judgment to do an exploratory operation. Doubtless, too, the field for surgery will be broadened and the mortality statistics improved if diagnosis is established in an early stage, and the patient is referred to the surgeon at a time sooner than he usually sees the case. The general practitioner must recognize and evaluate the significance of abnormal sensations in the cervical, re-

trosternal, and epigastric areas, and call upon the esophagoscopist, roentgenologist, and pathologist at any early time to help establish the diagnosis. If he waits until dysphagia is noticeable or until pain has developed, the growth will likely have reached an inoperable stage.

The alternative to surgery in curative treatment is radiotherapy. Here the statistics for recovery are at least no better, if as good. The majority of carcinomas of the esophagus are of the squamous cell type and are radioresistant. Guisez has reported several patients who have been treated by x-ray and survived a five-year period; Finzi, five years and ten years; Palugyen, one alive four years after combined x-ray and radium; Chevalier Jackson has recorded a similar result. But these apparent recoveries are exceptional. Most radiologists report palliative improvement in some cases, the result of diminution in the size of malignant growth with increase in patency for a brief period of time, and the extension of life for a few months. Souttar has discontinued the use of radium. All his patients so treated died within a year. He finds it impossible to gauge the dose for the individual case, and warns about the definite danger of necrosis and sloughing and perforation following its use. Levett thinks that success will follow intensive use of deep x-ray projected from various angles. We hope that as time goes on a technic will be perfected that will produce increasingly favorable results.

What then in the light of our present knowledge should be the future course of the surgeon? It would seem that he must still assume responsibility for the treatment of malignant growths of the esophagus, as he must elsewhere in the body. Shall he resign himself to 100 per cent mortality without treatment, to practically 100 per cent mortality under radiotherapy; or shall he courageously proceed with a surgical operation which carries a greater risk than he willingly cares to assume, and is certain to have a high mortality, even when backed by wide experience, meticulous care in its performance, careful study and selection of cases. For my own part, in spite of failure in my first and only operative case, the success of others, small as it is, has been stimulating rather than discouraging, and leads me to advocate surgical operation for suitable cases of malignancy of the esophagus.

Just which operative method to select for the thoracic esophagus is difficult. There has been no outstanding successful one. On the basis of record and because the technics are basically sound and well standardized, I should be inclined to favor, depending much upon the location of the tumor, the Torek, or Fischer, or the one of Zaaijer and Hedblom that prescribes a preliminary thoracoplasty. One must

really approach the case individually and be prepared to choose the method, or vary the technical details at the operating table in accordance with the findings.

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A REPORT OF A "PROVED CURED CASE" OF SQUAMOUS CELL EPITHELIOMA OF THE ESOPHAGUS TREATED BY INTRAESOPHAGEAL AND EXTERNAL IRRADIATION*

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CARCINOMA of the esophagus is a relatively common disease, but its treatment remains one of the most difficult problems in medicine. Its extremely high mortality may be appreciated when one remembers that the symptoms are usually insidious and are seldom diagnosed early. Furthermore, in most cases, the relatively radioresistant nature of the neoplasm and its inaccessibility present a therapeutic difficulty. Modern improvements in the field of radiation therapy, however, have made it possible to prolong life in a small percentage of cases.

The purpose of this paper is to report a "proved cured" case of a squamous cell epithelioma of the esophagus in its upper third, in which intraesophageal radiation by means of radium element was used in conjunction with intensive roentgen therapy.

CASE REPORT

P. McG. (No. 376480), a sixty-three-year-old Irish watchman, was admitted to the hospital April 26, 1933, complaining of difficulty in swallowing. This was noticed two months prior to his admission and became worse until even liquids were swallowed with difficulty. There was no history of cancer in the family. He had been a heavy smoker and a moderate drinker. Laboratory tests, including the Wassermann, were negative. Two successive x-ray studies by the opaque meal method showed an irregular constriction in the upper third of the esophagus. This was confirmed by the "sausage-skin" method which revealed a large filling defect, measuring 5.5 cm. in length. The growth extended from the level of the sixth cervical to the third dorsal vertebrae (Fig. 1). On May 16, esophagoscopy revealed a firm, ulcerated mass 22 cm. from the upper teeth. A piece of tissue was removed by a retrograde curette (Fig. 2) for biopsy.

On June 14, 1933, four 10 mg. radium tubes were inserted into a special applicator (Figs. 3 and 4), which was devised by one of us. This was applied accurately into the esophageal lumen, at the level of the neoplasm, so that it extended above and below the indurated edges. The position was checked by fluoroscopy and roentgenograms. Total length of radiating surface 10 cm. Distance 3 mm. from the center of the applicator to the esophageal mucosa. Filter 1 mm. platinum plus applicator metal, the latter being equivalent to 0.25 mm. platinum. Total linear dose was 800 mg. hr. given in twenty hours. About ten days after the treatment,

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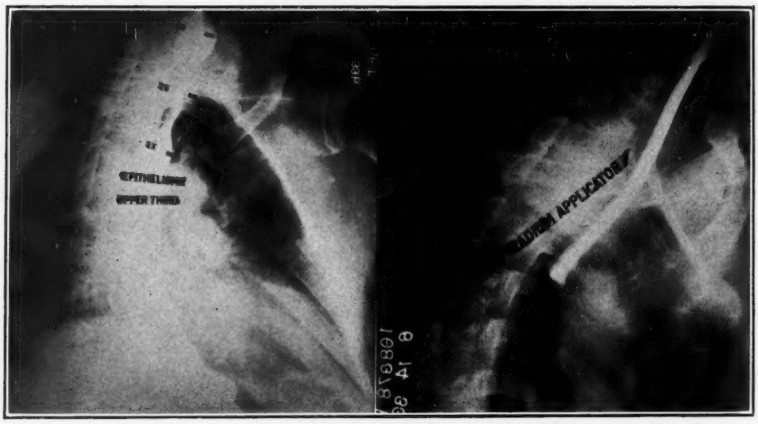
the patient complained of "sore throat" and increased difficulty in swallowing. This was attributed to the radium reaction since it subsided within two weeks. On September 22 x-ray studies by barium meal showed the esophageal lumen to be some-



A. *B.*

Fig. 1.—*A*, "Sausage skin" bougie. *B*, Applicator in place.

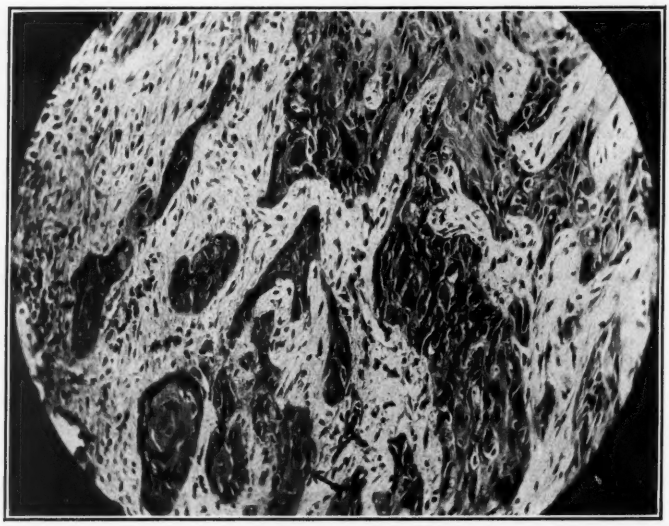
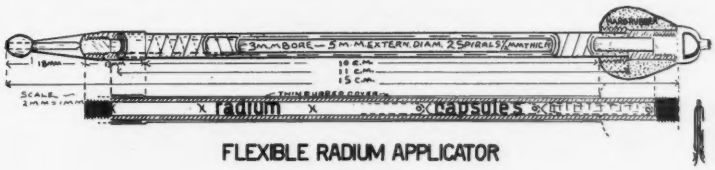


Fig. 2.—Arrow points to mitosis.

what wider. The patient, however, was losing weight constantly because of insufficient nourishment. On October 5 gastrostomy was performed, and three weeks later radium was applied in the same manner as described above. This was soon followed by a long series of deep roentgen therapy (from Nov. 13, 1933, to Feb. 16, 1934), in fractionated doses of 150 to 300 roentgens daily, by cross-firing the upper

third of the esophagus through four portals of 10 by 15 cm. A total of 1,800 roentgens were given through each of the anterior and posterior fields, and 2,400 roentgens through each of the lateral fields. After the completion of the series, the skin on the lateral fields showed marked erythema which subsided within a period of two weeks. About a month afterward, the patient began to swallow liquids with little difficulty. On March 22, 1934, esophagoscopic examination showed a persistent stricture, but no neoplastic tissue could be seen. Despite this observation, we were not quite convinced that the neoplasm was completely destroyed. The radium applicator was applied into the esophageal lumen for the third time under avertin anesthesia, but the treatment was not completed. About one and one-half



FLEXIBLE RADIUM APPLICATOR

Fig. 3.

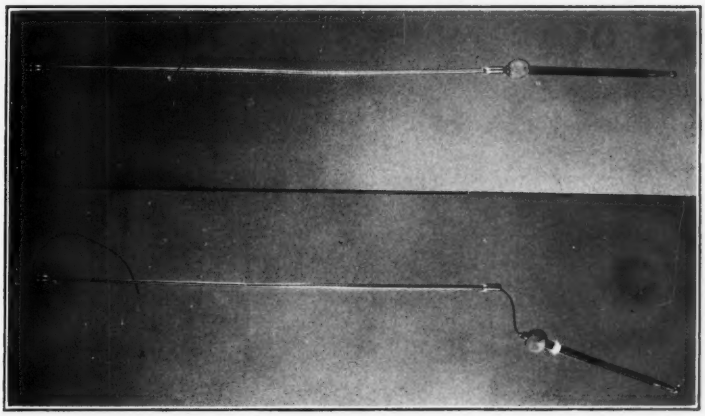


Fig. 4.

hours later, as he began to cough persistently, he was given 2 c.c. more of avertin to check it. Shortly thereafter, nasal oxygen was started because of cyanosis. Ten minutes later, however, respiration became shallow and he stopped breathing before CO_2 could be administered. Caffeine-sodium-benzoate was given and artificial respiration continued for half an hour without avail. It was believed at the time that the patient's death was due to the anesthesia.

Postmortem Findings: The extreme upper portion of the esophagus showed several irregular areas of congestion, and the mucosa here was thin, flat, and somewhat friable. At the level of the cricoid cartilage, there was a constriction in the esophagus extending over a distance of 3 cm., where the lumen of the esophagus is reduced to about one-half its normal caliber. The mucosa in this area was smooth and congested. There was fairly thick, dense, fibrous tissue present, but there was no evidence of tumor tissue in the vicinity. The regional lymph nodes were free

from tumor. There were no areas of ulceration or tumor formation present (Fig. 5). Microscopic Examination: The sections consisted of a fairly vascular, dense mass of fibrous scar tissue with no overlying mucosal structures. The mucosa was replaced by pale, fragmented, anuclear, fibrillar material, under which there was a wide layer of fibrous tissue, fairly extensively infiltrated with large numbers of dark round cells, polymorphonuclears and eosinophiles. The muscular layers were atrophic and most of the fibers showed attempts at regeneration. Abundant yellow pigment was scattered throughout. Nowhere in the sections was there evidence of tumor tissue.

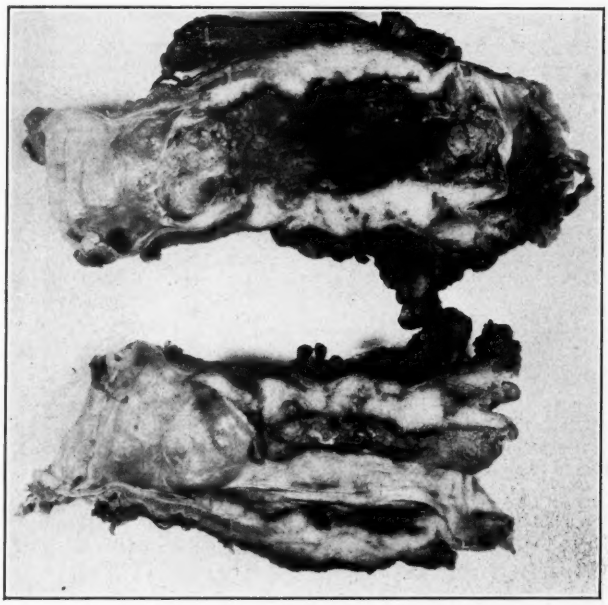


Fig. 5.

DISCUSSION

Intraesophageal irradiation by means of radium element in tubes is not new. It has been used notably by Guisez[1] for many years with occasional good results. Mattick[14] advocated a similar method with the added advantage of a heavier filtration, namely, 1.5 mm. platinum or its equivalent. He devised a new applicator made of a series of tandem tubes to accommodate 5 mg. radium element, which can be changed to any length. The main advantage of our applicator and method lies in the accuracy of measuring the tumor and correctly placing the radium applicator in position. After preliminary roentgen ray studies of the esophagus and a biopsy, the involved area is measured by means of the "sausage-skin" bougie,[11] provided with accu-

rately spaced metal rings which are at 5 cm. distance (Fig. 6*C*). After the instrument is passed down into the esophagus and the bag is inflated with the barium sulphate mixture, a roentgenogram is taken. The distended bag, as shown on the roentgenogram, will outline the entire esophageal wall, including the area of neoplasm. The metal rings can be distinctly seen, and the size of the neoplasm can be measured. If there is any distortion of the area to be measured on the film, the metal rings seen in the roentgenogram also will be proportionately distorted.

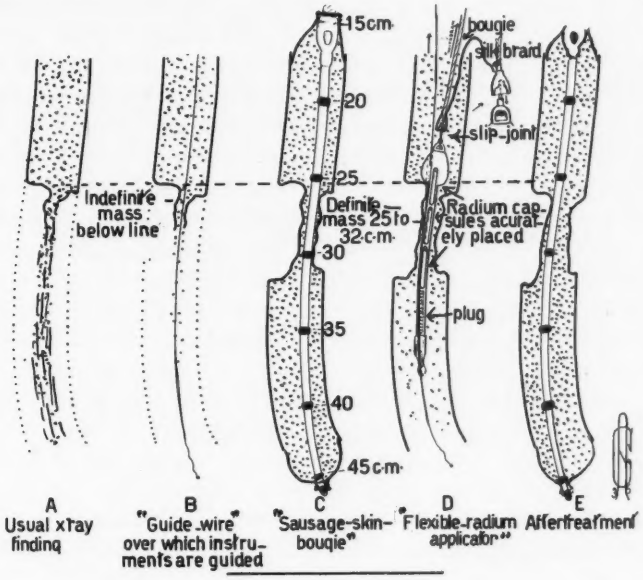


Fig. 6.

The intraesophageal radium applicator (Figs. 3 and 4) is a cylindrical container, made of two nickel spirals of 0.5 mm. thickness, by 2.5 mm. in breadth, wound in opposite directions, one superimposed upon the other. The tip of this applicator is unscrewed and loaded with radium tubes in tandem so as to extend beyond the limits of the lesion to be treated. A flexible tipped guide wire is then passed through the stricture.[11] Over this wire, the tip of the radium applicator is guided in place and slipped down the esophagus by a special bougie that engages the upper end of the applicator by a "slip" connection (Fig. 6*D*). The applicator is stopped in its downward passage when the upper bulbous end impinges against the upper margin of the neoplasm. In passing the applicator down the esophagus, the silk braid which is attached to its upper end is held taut in

the socket of the bougie. After placing the applicator in the esophagus, the silk braid is released and the bougie withdrawn, leaving the applicator in place. The silk braid is then held against the cheek by means of adhesive tape. It is preferable to run a small rubber tube over the braid to protect it from the teeth.

We agree with Mattick's contention that heavier filtration is more desirable but impractical, as it adds to the thickness of the applicator, thereby rendering its introduction through the contracted lumen of the esophagus more difficult. With our applicator it is within limits of safety to irradiate the esophageal lesion by applying 75 to 100 mg. hours per 1 cm. length. If the site of radiation is over 5 cm. in length, it is safer, perhaps, to limit the dosage to 75 mg. hours or less per 1 cm. length. Frequent intensive radiation with the radium applicator, aside from causing unnecessary trauma, may produce sloughing of the diseased tissues, followed by uncontrollable hemorrhage and perforation into the neighboring structures. In our opinion, external irradiation by means of x-rays should either precede or follow the intraesophageal radium application in almost every case. Considering the anatomy and microscopic pathologic condition of the esophageal carcinomas, it seems, as noted by Watson,[13] logical to expect more from roentgen therapy than from any other form of treatment. In the past we have treated a number of cases of carcinoma of the esophagus with combined use of radium element and roentgen ray, resulting in either palliation only or failure. The majority of these patients had far advanced lesions, and most of the neoplasms were in the middle or lower thirds of the esophagus, in close approximation to vital organs, thereby making approach difficult and hazardous. Moreover, none of them received an adequate amount of radiation therapy.

A serious difficulty is that the majority of these patients are poorly nourished, emaciated, and too weak to tolerate adequate treatment.

In selected cases, in which intensive external radiation is considered desirable, an early gastrostomy is essential. It is a well-known fact that following a vigorous course of irradiation a severe local reaction is certain to occur. Thus, one cannot expect the patient to receive nourishment through the esophagus. A chronic inflammatory esophagus, due to the presence of saprophytic organisms, stagnating detritus and organic acids, is always present. Therefore, an early gastrostomy is highly desirable to provide adequate maintenance of nourishment, to keep the esophagus at rest, and to minimize the local mixed infection.

We are aware of the fact that a report of a single proved case of an epithelioma of the esophagus, successfully treated by irradiation,

has no statistical value and does not imply that the treatment used can be expected to produce results in every case. In the treatment of this disease one has to realize the limitations of all forms of therapy irrespective of what method of approach is chosen. The type of treatment should be governed by the location of the tumor and the general condition of the patient. If the neoplasm is situated in the middle and lower thirds, symptoms appear comparatively late when the disease is usually far advanced. Accordingly, such cases are treated palliatively. On the other hand, if the neoplasm is situated in the upper third of the esophagus, a more favorable result may be expected because the symptoms occur relatively early. Furthermore, a neoplasm in this region can be cross-fired by external radiation through many portals with the least possible damage to the adjacent tissues. Up to the present, the treatment of carcinoma of the esophagus by irradiation is one of the hopeful methods, and the main reliance should be placed upon intensive high voltage roentgen therapy given in daily fractionated doses. In a very few cases, in which a cure is expected, a preliminary gastrostomy should always be performed as an important adjunct to maintain the patient's nourishment before attempting intensive radiation.

SUMMARY

1. A proved case of squamous cell epithelioma of the esophagus was treated with the combined use of radium by means of an intraesophageal applicator, and high voltage roentgen rays applied in fractionated daily doses. Subsequent postmortem examination revealed no trace of the tumor.

2. A new method of application of radium element into the esophagus is described.

3. The upper esophagus offers the most favorable site for radiation therapy on account of the early appearance of symptoms, less food stasis, generally a more limited tumor mass, and better portals for external radiation.

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DISCUSSION OF PAPERS ON "ESOPHAGOGASTROSTOMY FOR CARCINOMA OF THE ESOPHAGUS" BY DECKER; AND "A REPORT OF A 'PROVED CURED CASE' OF SQUAMOUS CELL EPITHELIOMA OF THE ESOPHAGUS TREATED BY INTRAESOPHAGEAL AND EXTERNAL IRRADIATION" BY CRUMP AND KASABACH

DR. HOWARD LILIENTHAL.—Reference was made to my case in which there was recovery lasting more than a year, the patient dying of metastases. No gastrostomy was performed nor jejunostomy. It is the only case on record in which a complete operation for thoracic esophagus cancer was done without gastrostomy. I do not believe that gastrostomy is necessary in most early cases.

You have heard from Dr. Decker about esophagostrostomy and I want to call your attention to my simpler method described in *Thoracic Surgery* (Saunders), Vol. 1. One patient survived four days and then died of pneumonia of the opposite lung. That patient was able to swallow almost immediately after the operation. She was given semisolid food. Esophagogastrostomy should be a first stage, followed a few days later by removal of the cancer itself.

DR. R. B. BETTMAN.—May I call attention to a type of gastrostomy that we have been using in Chicago. We call it the Spivack gastrostomy, after the man who first described it. His original description appeared in some obscure, foreign journal; therefore, his operation has not received the publicity that it deserves. The essence of the operation is that a mucosa-lined tube is formed from the anterior wall of the stomach to the exterior, and at the gastric end of this tube is a valve formed by an invagination of the coats of the stomach. This valve works so perfectly that gastric contents cannot leak out. At the time of feeding, a large catheter is inserted through the gastric tube into the stomach, and after the feeding has been completed, the catheter is removed. The construction of the tube prevents synechia, so that the tube stays patent. This type of gastrostomy is ideal for the treatment of esophageal stenosis.

The operative technic is simple and can be carried out in all instances except those in which the stomach has contracted to such as extent that the distance from the lesser to the greater curvature is less than two inches.

DR. CARL EGGERS.—Surgery for carcinoma of the esophagus must have two definite objectives, removal of the tumor and reestablishment of the function of deglutition. Both objectives would at the present time be more readily realized with carcinoma of the cardia than with carcinoma in any other portion of the esophagus, were it not for the fact that most cases are diagnosed too late. The case reported by Dr. Decker, on which he operated according to the method described by Dr. Fischer of New York in the *Archives of Surgery*, January, 1926, illustrates these points.

I want to take this occasion to add another case operated on by me in 1933, in which the same principles, namely, resection of the tumor with closure of the lower stump and implantation of the esophagus into the fundus of the stomach, were applied. Several of the details of technic described by Fischer were found not to be practical, and it is questionable whether they are sufficiently important to stress them.

A. F., a male patient fifty years of age was admitted to Lenox Hill Hospital, February 15, 1933, complaining of pain and difficulty with swallowing. His symptoms dated back nine months when in May, 1932, he vomited and noticed blood;

Fig. 1.—Extensive carcinoma involving lower esophagus, cardia, and upper end of stomach.

without pain or other symptoms. From that day on he had a little trouble swallowing, he would vomit occasionally, but never noticed blood again. Symptoms had gradually become worse, and during the last five weeks he had pain in addition to increased dysphagia. Pain was situated chiefly under the lower end of the sternum and radiated to the right side. During the last few days it was present constantly, and was sufficiently severe to awaken him at night. He was able to swallow soft cereals, eggs, and fluids, but solid food seemed to stick in the lower chest and caused distress. When he took water to wash it down, a sound like belching was produced. He had lost 12 to 14 pounds.

Except for these symptoms his history was negative. His family physician had fluoroscoped him a few days before admission, made a correct diagnosis, and referred him for operation.

General examination showed no gross abnormality. Wassermann test was negative. X-ray examination showed an obstructing lesion affecting the lower end of the esophagus, interpreted as a carcinoma (Fig. 1). Esophagoscopy showed a tumor mass 15½ inches from the teeth, which suggested malignancy. A biopsy was reported carcinoma. It was decided not to do a gastrostomy because it might interfere with proper mobilization of the stomach, but rather to resect the tumor and to implant the esophagus as suggested by Fischer.

An incision was made along the left ninth intercostal space. For good exposure it was necessary to divide the ninth and eighth ribs posteriorly. After inserting a

Fig. 2.—Showing successful implantation of esophagus stump into fundus of stomach.

rib spreader, normal looking lung and diaphragm presented. A tumor was felt in the lower esophagus. It did not involve the overlying pleura. The latter was incised and a tape passed around the esophagus above the tumor. The phrenic nerve was divided and the diaphragm was then split. The growth involved the lower esophagus, the cardia, and the upper end of the stomach. One enlarged lymph node was encountered and removed. After the esophagus had been divided with a cautery between ligatures above the growth, gentle traction on the lower stump ligature aided greatly in freeing the entire mass. Double clamps were applied below the growth, the stomach was divided, and the specimen removed. The stomach opening was then closed, using chromic catgut for the inner and silk for the outer suture, and reinforcing with a few interrupted sutures. The size of the stomach was considerably reduced by this procedure and additional mobilization was required to permit it being drawn up into the chest. It was carried well up behind the esophagus and fastened into place with

one suture about two inches above the esophagus stump. The posterior wall of the esophagus was then united to the anterior wall of the stomach by means of interrupted sutures along both sides and at the lower end. A small opening was then made into the stomach opposite the esophageal lumen from which the ligature had previously been removed, and the two margins were united with interrupted chromic catgut. The anterior stomach wall was then drawn upward in front of the esophagus and fastened to its anterior surface. A few lateral sutures were placed to obtain snug fitting. The esophagus was thus invaginated into the stomach for about two inches without any undue tension.

A drainage tube was inserted into the old esophageal bed of the lower mediastinum behind the newly formed esophagogastrostomy and led out through a puncture wound in the tenth intercostal space.

The diaphragm was partly closed, and the remaining margins were sutured to the stomach to prevent herniation. The chest wall was completely closed in layers. Toward the end of the operation the lung was expanded and kept that way with the end of the drainage tube under fluid level.

The patient was considerably shocked, and was given a transfusion. His recovery was quite satisfactory, however. Fluids were given subcutaneously and intravenously, and from the fourth day on he was also permitted to take small drinks. They produced no distress. X-ray examination showed good expansion of the lungs. Drainage was slight; at first the fluid was sterile, but later there was a positive culture of *Staphylococcus aureus* and short chain streptococcus.

During the entire postoperative period the patient ran a temperature ranging from 101° to 104°. The wound healed by primary union. There was no complaint on his part. X-ray examination was negative. Mediastinitis was suspected but could not be positively diagnosed.

The patient died eleven days after operation.

An autopsy was performed, which showed a mediastinal abscess, containing 2 c.c. greenish pus, well encapsulated, as the cause of death. It was surrounded by the stomach, the diaphragm, and the pericardium. No perforation could be demonstrated, and the impression was gained that the abscess was due to soiling at the time of operation. It might have been better had the esophageal stump not been opened, but transplanted into the stomach closed off with a plain catgut ligature.

The pathologic report was adenocarcinoma with metastatic involvement of one lymph node.

The most interesting part of the autopsy was the specimen, which showed a firm implantation of the esophagus stump into the stomach. The outer muscular wall of the esophagus was found completely adherent to the serosa of the stomach (Fig. 2), and showed conclusively that it is not necessary to have serosal surfaces in contact in order to obtain healing.

Though we lost the patient, the case encourages one to carry on along this line.

DR. FREDERICK T. LORD.—May I ask Dr. Crump what the chances of developing skin cancer may be after so much external radiation?

DR. FRANK S. JOHNS.—May I ask Dr. Crump, was there hemorrhage in this application of radium? I was interested in Dr. Crump's results. One of our patients had a fatal hemorrhage following the combined x-ray and radium treatment. I should like to know whether hemorrhage has been a troublesome factor.

DR. HARRY R. DECKER.—I can see one distinct advantage of preliminary gastrostomy aside from the point of improving the patient's general condition for radical operation. That is, it gives the method for postoperative feeding, and puts the suture line at rest. If there is slight infection, I think it minimizes the chance for spread of it and affords a chance of localization.

DR. ARMISTEAD CRUMP.—Dr. Kasabach, unfortunately, could not be here to answer the problem of the radiation therapy; however we have had no trouble with the Coutard or rather our modification of the Coutard method.

We have had no case of skin cancer as a result of treatment, of any severe erythema that did not resolve itself within a very short period. Of course, there is a great deal of swelling of the throat, the pharynx, and so forth, up to the point of absolute inability to swallow anything, and that is the reason we advised the primary gastrostomy.

We have not seen hemorrhage in any of the cases that we have treated. Of course, the lower esophagus is entirely one for the surgeon. We do not think radium, or x-ray, have a bit of curative effect in the lower esophagus; radium will relieve the pain, but that is about all.

The question is quite appropriate at this time. In the May 4th issue of the *Journal of the American Medical Association* there is a report* of "Roentgen Radiation Necrosis of Larynx and Other Structures." We have been fortunate in not having such severe reactions on account of frequent small doses and the use of proper filtration.

*Nelson and Hirsch.

CONTRIBUTIONS TO THE TECHNIC OF PULMONARY EMBOLECTOMY*

An Experimental Study

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IT IS estimated that embolism of the pulmonary arteries is responsible for approximately 6 per cent of the deaths which occur following operations on patients. The number of instances in which attempts have been made to relieve the obstruction of the artery is relatively small. This is due largely to three reasons. First and most important is the fact that one cannot be certain as to the correct diagnosis in all instances. Second, death occurs in about half of the cases less than ten minutes following the onset of the embolism, and very little time is allowed for the preparation and performance of the operation. Third, even a very severe attack of pulmonary embolism may result in spontaneous recovery. In the instances in which the condition is diagnosed and in which there is sufficient time for the preparation for the operation, a further difficulty lies in the fact that the removal of the embolus from the artery has to be performed quite speedily. It has been in an effort to find a means whereby the length of time can be extended during which the pulmonary artery may be occluded during the performance of embolectomy that these experiments were undertaken.

In one of his early communications, Trendelenburg[1] stated that the technical occlusion of the circulation in performing the embolectomy could be tolerated for not longer than two minutes, and he thought it inadvisable to occlude it for more than forty-five seconds. He found in his experiments that compression of the pulmonary artery and aorta has the same effect as that produced by occlusion of the pulmonary artery alone. In one of Crafoord's[2] operations (Case No. 2) the pulmonary artery and aorta were occluded for sixty-one seconds. In five of the cases of Nyström,[3] which were successful from a technical viewpoint, occlusion of the pulmonary artery and aorta was maintained for 60, 65, 75, 104, and 105 seconds. The last two figures represent the occlusion periods in two patients who recovered completely. From these observations Nyström concluded that it would seem under fa-

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†Abraham Flexner Lecturer in Surgery at Vanderbilt University School of Medicine in 1935.

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vorable conditions that a complete suspension of the circulation for nearly two minutes is not necessarily incompatible with the persistence of life.

In experiments upon rabbits, Läwen and Sievers[4] found that obstruction would cause death after lasting more than two and a half minutes. But by the aid of different kinds of resuscitative measures, the animals could be revived, even if the obstruction had been prolonged seven to eight minutes. Stewart, Guthrie, Burns, and Pike[5] and Houssay and Hug[6] interrupted the cerebral circulation for periods varying from three to eighty-one minutes by ligation of the innominate and left subclavian arteries proximal to the origin of the vertebral. This procedure and occlusion of the pulmonary artery and aorta do not, however, result in identical effects.

As has been stated, the present experiments were performed in an effort to find a means by which a longer occlusion of the pulmonary circulation could be produced and still have the subject recover. A period of 45 to 100 seconds is a very short time in which to carry out such a procedure and particularly so since it is an operation which places the team of surgeons in such a high degree of nervous tension. It was felt that the addition of even one minute to the time during which the circulation could be interrupted would add greatly to the better performance of the operation. Even though it is possible in some cases, as in the last successful one of Crafoord,[7] to perform the embolectomy without completely occluding the vessels, one should have available adequate means for preventing excessive loss of blood.

METHODS

Dogs were used as the experimental animals in all instances. The blood pressure was obtained by placing a cannula, which was connected to a mercury manometer, into the femoral artery. In the first few experiments, anesthesia was produced by the intravenous introduction of nembutal. The dosage used was 25 mg. per kilogram of body weight. In the remaining experiments, anesthesia was produced by a preliminary injection of morphine (0.017 gm.) and by inhalation anesthesia of ether. It is impracticable in the dog to approach the pulmonary artery without entering the pleural cavity, and hence an intratracheal tube with positive pressure was used. An intercostal incision was made on the left side of the chest, the ribs were spread and the pericardium was exposed. A longitudinal incision was made in the pericardium which allowed the pulmonary artery and aorta to be visualized. Occlusion of the vessels was produced by passing around them a special clamp which was devised recently by one of us (G. N.). This is shown in Fig. 1. After the occlusion had been produced for the desired length of time, the instrument was removed and an attempt was made to resuscitate the heart unless spontaneous

beats appeared. These means consisted usually of the injection of 1 c.c. of adrenalin into the aorta and of massage of the heart. If the heartbeats and respiratory movements reappeared, the chest was closed and the animals were observed for varying intervals of time up to seventeen hours. These experiments constituted a so-called *control group.*

In a second group of experiments the pulmonary artery and aorta were occluded in the usual manner and defibrinated blood was introduced into the aorta between the clamp and the heart. The idea of the introduction of blood was to perfuse the coronary vessels. The length of time elapsing between the occlusion of the vessels and the beginning of the introduction of the blood varied from thirty seconds

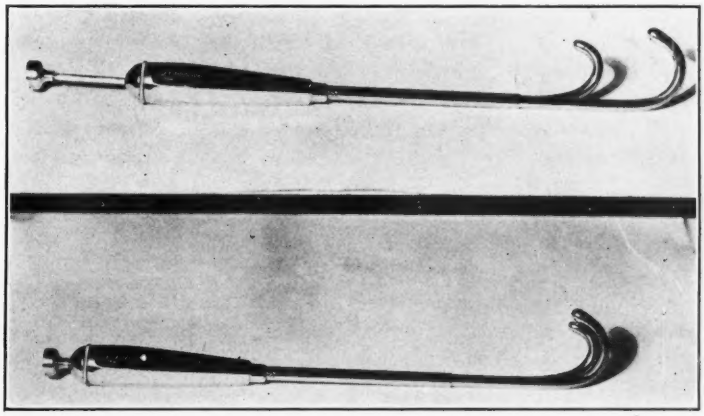

Fig. 1.—Clamp used for occluding the vessels in these experiments. Clamp is shown open and closed.

to two minutes. A syringe with a three-way stopcock and a needle was used for the introduction of the blood. An attempt was made to introduce it at a constant rate throughout the remaining part of the occlusion period. The amounts introduced varied from 170 to 510 c.c., and the weights of the dogs ranged from 6.8 to 18.2 kg.

In a third group of experiments, defibrinated, oxygenated blood was introduced into one of the carotids as well as into the aorta during the time that the pulmonary artery and the aorta were occluded. The idea in these experiments was to maintain some circulation to the brain as well as to the heart muscle during the occlusion period. The interval separating the beginning of the occlusion period and the injection of blood varied from forty-five seconds to two minutes and fifteen seconds. The quantities of blood introduced into the aorta in these experiments varied from 215 c.c. to 560 c.c., whereas that injected into the carotid ranged from 160 c.c. to 450 c.c.

In the fourth group of experiments the pulmonary artery alone was occluded by the use of the same clamp which was used when both the pulmonary artery and the aorta were obstructed. No blood was introduced in these experiments.

In the fifth group of experiments the same procedure was carried out as has been described for the first group, that is, both the pulmonary artery and the aorta were occluded and no blood was introduced. The procedure, however, differed slightly from that used in the first group in that a small incision was made in the pericardium and in that adrenalin and massage were used almost immediately following the release of the occlusion.

RESULTS

Group I. Studies on the Effects of Occlusion of the Pulmonary Artery and Aorta. Twelve experiments of this type were performed. In two of these the occlusion periods were only three minutes, and they will be omitted from the consideration as prompt recovery occurred. In the remaining ten experiments the occlusion periods varied from five minutes to seven minutes. In four of the ten experiments there was a resumption of the heartbeats and respiratory movements following the release of the arteries. The duration of the occlusion periods in these four experiments was five minutes, five minutes, five minutes and thirty seconds, and six minutes and fifteen seconds. In the remaining six experiments there was no sustained return of the heartbeat and respirations. In one of these, the heart beat returned, but fibrillation occurred thirteen minutes and forty-five seconds later, and the heart's action soon ceased completely. The injection of adrenalin into the aorta and massage were used in all of the experiments except two. The results of these studies are to be found in Table I.

The impression which was gained from these studies was that the maximum period of occlusion of the pulmonary artery and aorta which could be tolerated by the dog was approximately six minutes and even then that death would occur in the majority of the cases.

Group II. The Effects of Occlusion of Pulmonary Artery and Aorta With Simultaneous Injection of Blood Into the Aorta Proximal to the Occlusion. Eleven experiments of this type were performed. The duration of the occlusion of the pulmonary artery and aorta varied from seven minutes and forty-five seconds to ten minutes. A sustained return of the heartbeat and respirations occurred in six of the eleven experiments. The duration of the occlusion period in these six experiments varied from seven minutes and forty-five seconds to nine minutes. The heart appeared to be in better condition during the occlusion period in these experiments than in those studies in which no blood was introduced. The color was better and the beats were

TABLE I

EFFECTS OF OCCLUSION OF PULMONARY ARTERY AND AORTA

EXP. NO.	DURATION OF OCCLUSION	ADRENALIN AND MASSAGE. TIME USED AFTER RELEASE	RETURN OF HEARTBEAT AND RESPIRATIONS	ANESTHETIC	REMARKS
1 19.0 kg.	5 minutes	None	Both	Nembutal	Apparently complete recovery.
9	7 minutes	Adrenalin 3′ 15″ Massage 4′ 40″	No	Nembutal	
11 9.8 kg.	7 minutes	Adrenalin 3′ 15″ Massage 8′	No	Nembutal	
19 9.5 kg.	5 minutes	Adrenalin 2′ 30″ Massage 8′	No	Morphine and ether	
20 12.1 kg.	5 minutes	None	Both	Morphine and ether	Apparently complete recovery. Observed for 35 minutes.
24 6.5 kg.	6′ 45″	Adrenalin 30″ Massage 55″	No	Morphine and ether	
25 11.0 kg.	6′ 45″	Adrenalin 15″ Massage 1′ 15″	No (temporary)	Morphine and ether	Fibrillation began 13′ 45″ after releasing occlusion. Heartbeats and respirations present to that time.
26 6.0 kg.	5′ 45″	Adrenalin 30″ Massage 57″	No	Morphine and ether	With heart massage, respiratory movements continued for 31′ following release of occlusion.
27 8.8 kg.	5′ 30″	Adrenalin 20″ Massage 37″	Both	Morphine and ether	Apparently complete recovery. Observed for 90 minutes.
30 9.1 kg.	6′ 15″	Adrenalin 17″ and 2′ 45″ Massage 2′ 15″	Both	Morphine and ether	Respirations quite jerky at first. Observed for 35 minutes. Apparently all right.

TABLE II

EFFECTS OF OCCLUSION OF THE PULMONARY ARTERY AND AORTA WITH THE SIMULTANEOUS INJECTION OF BLOOD INTO THE AORTA PROXIMAL TO THE OCCLUSION

EXP. NO.	DURATION OF OCCLUSION	QUANTITY BLOOD INTRODUCED C.C.	INTERVAL BETWEEN OCCLUSION AND BEGINNING INJECTION	ADRENALIN AND MASSAGE. TIME USED AFTER RELEASE	SUSTAINED RETURN OF HEARTBEAT AND RESPIRATIONS	TIME RESPIRATIONS RETURNED AFTER RELEASE	TIME EYE REFLEXES RETURNED AFTER RELEASE	ANESTHETIC	REMARKS
15 18.2 kg.	9 min.	510	30″	Adrenalin 2′ 35″	No (temporary)	15′		Nembutal	Temporary return of heartbeat and respirations. Died 30′ following release.
18 8.3 kg.	8 min.	400	30″	None	Both	7′	25′	Morphine and ether	Observed for 4′ 40″. Condition all right.
28 7.75 kg.	10 min.	230	1′ 45″	Adrenalin 50″ Massage 1′ 30″	No			Morphine and ether	Heart beat well for first 9′ of occlusion period. Air in coronaries at autopsy.
32 8.3 kg.	8′ 20″	170	1′ 10″	Adrenalin 20″ Massage	Both	3′ 50″	23″	Morphine and ether	Observed for 2 hours. Condition all right.
33 7.5 kg.	8′ 30″	175	1′ 15″	Adrenalin 30″	No (temporary)	6′		Morphine and ether	Fibrillation began 7′ 15″ after release. Blood pressure high at time.
34 6.8 kg.	8 min.	175	1′ 20″	Adrenalin 1′ 15″ Massage 2′	Both	6′ 15″	28′	Morphine and ether	Observed for 75 minutes. Condition all right.
35 14.4 kg.	8 min.	170	2″	Adrenalin 1′ 20″ Massage 2′	No			Morphine and ether	
36 14.0 kg.	9 min.		1′ 15″	Adrenalin 50″ Massage 2′ 10″	No			Morphine and ether	Heart beat well for first 8 minutes of occlusion.
37 8.2 kg.	7′ 45″	215	1′ 20″	Adrenalin 1′ 50″ Massage 2′ 55″	Both	5′ 30″	22′	Morphine and ether	Observed for 32 minutes. Condition all right.
39 9.9 kg.	9 min.	250	1″	Adrenalin 1′ 45″	Both	4′ 30″	15′	Morphine and ether	Respirations quite jerky for 15′. Observed 45′. Condition all right.
40 10.4 kg.	8′ 30″		1″	Adrenalin 50″	Both	10′	Not recorded	Morphine and ether	

stronger. Adrenalin and massage were used in most instances in resuscitating the heart. Spontaneous respirations returned at intervals varying from three minutes and fifty seconds to fifteen minutes following the removal of the clamp, and the eye reflexes returned at periods varying from fifteen to twenty-eight minutes. The results of these experiments are given in Table II.

A comparison of the results of these studies with those in Group I, in which no blood was introduced into the aorta, led us to believe that definite benefit resulted from the injection of the blood.

Group III. The Effects of Occlusion of the Pulmonary Artery and Aorta With Simultaneous Injection of Blood Into the Aorta Proximal to the Occlusion and Into the Carotid. Eight experiments of this type were performed. The occlusion periods varied from eight minutes to eleven minutes and ten seconds. There was a sustained return of the heartbeat and respirations following the release of the constriction in four of the eight experiments. The occlusion periods following which recovery took place were eight minutes, eight minutes, ten minutes, and ten minutes and forty-five seconds. The interval separating the release of the occlusion and the appearance of spontaneous respirations varied from three minutes to five minutes and fifteen seconds, and eye reflexes appeared after intervals varying from fourteen minutes to nineteen minutes and fifteen seconds. The results of these studies are to be found in Table III.

A comparison of these studies with those performed in the previous group, in which blood was introduced only into the aorta, gave us the impression that perhaps some benefit is to be derived from the injection of blood into the carotid as well. This point, however, was not proved. It seems very definite, however, that spontaneous respirations and eye reflexes reappear earlier when blood is introduced into the carotid.

In summary, thus far, of the experiments which were carried out with as nearly identical technics as we could use, there was definite evidence that occlusion of the pulmonary artery and aorta is tolerated better if blood is introduced into the aorta in the region of the coronary orifices. The evidence that the introduction of blood into the carotid was a valuable asset was less striking.

Group IV. A Study of the Effects of the Occlusion of the Pulmonary Artery Alone. During the early part of the studies, the heart was observed following the occlusion of the pulmonary artery alone for short intervals of time. It was noted that the heart seemed to dilate somewhat and that the beats became quite infrequent. It was thought at the time when a study of the effects of more extended occlusions was undertaken that occlusion of the pulmonary artery alone would be less well tolerated than occlusion of both the pulmonary artery and the aorta. Since the occlusion periods in four experiments were less

TABLE III

EFFECTS OF OCCLUSION OF THE PULMONARY ARTERY AND AORTA WITH THE SIMULTANEOUS INJECTION OF BLOOD INTO THE AORTA PROXIMAL TO THE OCCLUSION AND INTO THE CAROTID

EXP. NO.	DURATION OF OCCLUSION	QUANTITY BLOOD INTRODUCED AORTA C.C.	QUANTITY BLOOD INTRODUCED CAROTID C.C.	INTERVAL BETWEEN OCCLUSION AND BEGINNING INJECTION	ADRENALIN AND MASSAGE. TIME USED AFTER RELEASE	SUSTAINED RETURN OF HEARTBEAT AND RESPIRATIONS	TIME RESPIRATIONS RETURNED AFTER RELEASE	TIME EYE REFLEXES RETURNED AFTER RELEASE	ANESTHETIC	REMARKS
14 10.3 kg.	8 min.	510	450	45″	Adrenalin 3 min.	Both	3 min.	Not observed	Nembutal	Died from hemorrhage into chest.
17 9.9 kg.	8 min.	460	390	30″	None	Both	Approximately 3 min.	14 min.	Morphine and ether	Observed for 50′. Condition all right.
21	9′ 30″					No				Record of experiment lost.
22	10 min.	560	350	1′ 50″	Adrenalin 2′ 15″	Both	3′ 15″	18 min.	Morphine and ether	Observed for 70′. Condition all right.
23 8.8 kg.	10′ 45″	280	360	2 min.	Adrenalin 45 sec.	Both	5′ 15″	19′ 15″	Morphine and ether	Observed for 4 hours. Some bleeding into chest.
31 10.5 kg.	11′ 10″	250	250	2′ 15″	Adrenalin 20″ Massage 1′ 30″	No			Morphine and ether	Fibrillation. Tried to breathe 5′ 50″ after release and this continued for 6′.
38 9.2 kg.	9′ 30″	300	200	1′ 10″	Massage 55″ Adrenalin 1′ 25″	No			Morphine and ether	Fibrillation. Attempt to breathe 6′ 30″ after release.
41 7.4 kg.	10 min.	215	160	1′ 15″	Adrenalin 1 min.	No			Morphine and ether	Fibrillation.

TABLE IV

EFFECTS OF OCCLUSION OF PULMONARY ARTERY ALONE

EXP. NO.	DURATION OF OCCLUSION	ADRENALIN AND MASSAGE. TIME USED AFTER RELEASE	RETURN OF HEART-BEAT AND RESPIRATIONS	ANESTHETIC	REMARKS
42 10.1 kg.	5 min	Adrenalin 40″ Massage 1′ 10″	No	Morphine and ether	Attempt to breathe 2′ 30″ after release.
47 13.3 kg.	5 min	Adrenalin 1′ Massage 2′	Both	Morphine and ether	Observed for 30′. Apparently all right. Respirations began 3′ 30″ after release and eye reflexes 17′.
48 7.4 kg.	5′ 45″	Adrenalin 55″ and 1′ 30″ Massage 1′ 45″	Both	Morphine and ether	Observed for 32′. Apparently all right.
49 9.7 kg.	5 min	Adrenalin 55″ Massage 1′ 30″	Both	Morphine and ether	Observed for 40′. Apparently all right.
50 10.3 kg.	5′ 45″	Adrenalin 35″ Massage 1′ 15″	Both	Morphine and ether	Respirations began 2′ 35″ after release and eye reflexes 10′ 45″. Observed for 25′. Apparently all right.
51 10.0 kg.	6′ 30″	Adrenalin 25″ Massage 1′	Both	Morphine and ether	Respirations began 4′ 30″ after release and eye reflexes 14′ 30″. Observed for 23′. Apparently all right.
52 9.3 kg.	7 min.	Adrenalin 35″ Massage 50″	Both	Morphine and ether	Respirations began 4′ after release and eye reflexes 13′. Observed for 20 hours. Apparently all right.
53 11.9 kg.	8 min.	Adrenalin 45″ Massage 1′ 15″	Both	Morphine and ether	Respirations began 7′ 15″ after release and eye reflexes 24′. Observed for 95′. Apparently all right.
54 12.1 kg.	9 min.	Adrenalin 25″ Massage 35″	Both	Morphine and ether	Respirations began 3′ 30″ after release. At end of 4 hours pulse 110, respirations 24. Condition all right.
57 15.15 kg.	8 min.	Adrenalin 25″ Massage 35″	Both	Morphine and ether	Breathing returned 3′ and eye reflexes 19′. Observed for 75′. Apparently all right.
60 13.3 kg.	10′ 30″	Adrenalin 30″ Massage 40″	Both	Morphine and ether	Breathing returned 4′ 10″. Eye reflexes returned 17′ 30″. Observed for 90 minutes.
61 14.5 kg.	10′ 30″	Adrenalin 40″ Massage 55″	Both	Morphine and ether	Breathing returned 4′ 10″. Eye reflexes returned 17′ 30″. Observed for 17 hours. Dog moves around but is unable to stand alone.
64 7.6 kg.	12 min.	Adrenalin 25″ Massage 38″	No (temporary)	Morphine and ether	Heartbeat resumed but fibrillation began. Attempt to breathe 8′ 45″ after release.

than five minutes and since recovery took place in each instance, they will be omitted from further consideration. Thirteen experiments were performed in which the period of constriction varied from five minutes to twelve minutes. In eight of these the occlusion period was greater than six minutes. A sustained return of the heartbeat and respirations took place in eleven of the thirteen experiments. The

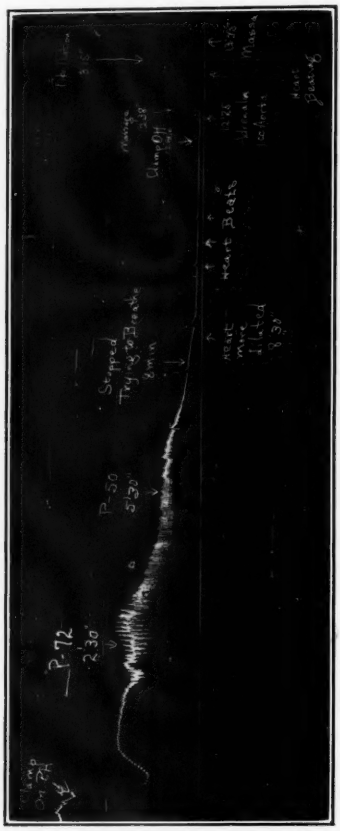

Fig. 2.—Chart reads from left to right. It is to be observed that the systemic blood pressure fell as soon as the pulmonary artery was occluded, but definite arterial pulsations continued for approximately seven minutes.

exceptions were one experiment in which the duration of the occlusion of the pulmonary artery was five minutes and another in which it was twelve minutes. In the latter experiment the heart began to beat forcibly following the use of adrenalin and massage but ceased when fibrillation began. This animal attempted to breathe eight minutes and forty-five seconds following the release of the occlusion. In the two experiments in which the artery was constricted for ten minutes and thirty seconds, recovery took place. One of these animals was observed for seventeen hours. At that time the animal would not

stand alone and appeared to be quite weak. Adrenalin and massage were used in all the experiments in which a long period of occlusion was maintained. The results of these experiments are given in Table IV.

The charts of the blood pressure of these experiments showed a rather striking difference from those which were obtained in the ex-

Fig. 3.—Showing the effects of occlusion of the pulmonary artery and aorta. Chart reads from left to right. Quite naturally, there was a total absence of pulsations in the arteries during the occlusion period and the blood pressure fell to a very low level.

periments in which the pulmonary artery and aorta were both occluded. During the first several minutes of the occlusion period, fairly strong pulsations in the femoral artery were recorded. In one experiment this definite pulsation continued for seven minutes. This is shown in Fig. 2. The blood pressure was not so high in most of the experiments. There is no doubt but that the occlusion of the pulmonary artery alone is associated with a continued although diminished supply of blood to the brain for at least several minutes. For

comparison, the blood pressure chart of an experiment in which the pulmonary artery and aorta were occluded is given in Fig. 3.

In summary, the results of these experiments indicated that occlusion of the pulmonary artery is tolerated better than occlusion of the pulmonary artery and aorta, even when blood is injected in the

TABLE V

FURTHER STUDIES ON THE EFFECTS OF OCCLUSION OF THE PULMONARY ARTERY AND AORTA

EXP. NO.	DURATION OF OCCLUSION	ADRENALIN AND MASSAGE. TIME USED AFTER RELEASE	RETURN OF HEARTBEAT AND RESPIRATIONS	ANESTHETIC	REMARKS
43 11.2 kg.	6 min.	Adrenalin 25″ Massage 1′	No	Morphine and ether	Fibrillation 2 minutes after release.
44 16.4 kg.	5′ 20″	Adrenalin 30′ Massage 1′ 40″	No (temporary)	Morphine and ether	Three minutes after release heart beat for several minutes but fibrillation occurred.
46 7.5 kg.	7′ 48″	Adrenalin 27″ Massage 47″	No	Morphine and ether	No resumption of heartbeats or respirations.
55 14.25 kg.	7 min.	Adrenalin 25″ Massage 40″	Both	Morphine and ether	Breathing returned 3′ 25″ and eye reflexes 19′. Observed for 35′. Apparently all right.
56 15.65 kg.	8 min.	Adrenalin 25″ Massage 35″	No	Morphine and ether	No return of heartbeat and respirations.
58 8.1 kg.	9 min.	Adrenalin 25″ Massage 40″	Both	Morphine and ether	Respirations returned 4′ 30″ and eye reflexes 24′. Observed for 42′. Apparently all right.
59 11.0 kg.	9 min.	Adrenalin 20″ Massage 35″	Both	Morphine and ether	Respirations returned 5′ 45″ and eye reflexes 16′. Observed 60′. Apparently all right.
62	10′ 30″	Adrenalin 20″ Massage 40″	No	Morphine and ether	Fibrillation began 1′ 20″ after release of occlusion.
63	10′ 30″	Adrenalin 20″ Massage 30″	Both	Morphine and ether	Respirations returned at 8′ and eye reflexes at 21′ 30″. Observed for 17 hours. Unable to stand but moves various muscles.

neighborhood of the coronary orifices in the latter experiments. Before being absolutely sure of this point, however, it was thought that some additional experiments on the effects of occlusion of the pulmonary artery and aorta should be carried out.

Group V. Studies on the Occlusion of the Pulmonary Artery and Aorta. In carrying out further studies on the effects of occlusion of the pulmonary artery and aorta an attempt was made to perform

them in as nearly an identical manner as possible to that which had been exercised in occlusion of the pulmonary artery alone. Without being definitely conscious of the change at the time, a smaller opening had been made in the pericardium in the experiments in which the pulmonary artery alone was occluded and adrenalin and massage had been used at an earlier period following the release of the occlusion. It is possible also that the method of massage had been improved upon. Briefly, this consisted in introducing the hand into the chest and outside the pericardium and pressing the heart between the hand and the sternum. An attempt was made to make the pressure from the apex toward the base. The heart was pressed four or five times in this manner between the hand and the anterior chest wall as soon as possible after the adrenalin had been injected.

Nine of these additional experiments were performed in which the pulmonary artery and aorta were occluded. The duration of the occlusion varied from five minutes and twenty seconds to ten minutes and thirty seconds. There was a sustained return of the heartbeat and respirations in four of the nine experiments. The durations of the occlusion period in these experiments were seven minutes, nine minutes, nine minutes, and ten minutes and thirty seconds. Adrenalin and massage were used in all experiments. The respirations were somewhat more jerky and labored than those which were observed in the experiments in which the pulmonary artery alone was occluded. The results of these nine experiments are to be found in Table V.

The maximum occlusion period which was followed by recovery in this group of experiments was ten minutes and thirty seconds, which was the same maximum period that was observed in the experiments in which the pulmonary artery alone was occluded. The percentage of the experiments in which recovery took place following the occlusion of the pulmonary artery alone was, however, much higher than that obtained in this group of studies.

DISCUSSION

The experiments in the first three groups were performed in almost identical manners in that a rather large opening was made in the pericardium, and adrenalin and massage were used when it semed that the heart would not resume beating without them. From the first group in which the pulmonary artery and aorta were occluded, it was concluded that the maximum occlusion period following which recovery would take place was approximately six minutes. The results of the second group of experiments, in which the pulmonary artery and aorta were clamped and blood was injected into the aorta between the heart and the clamp, indicated that the occlusion period could be extended two or three minutes as a result of this introduction of blood. There was no doubt but that the color of the heart

muscle was better and the pulsations were stronger. The results of the third group of experiments, in which blood was introduced into the carotid as well, suggested but did not prove that this additional procedure was of benefit. The respiratory movements returned in all experiments in which the beating of the heart was resumed. The initial respiratory movements, however, were less jerky and more regular in the experiments in which blood was injected into the carotid. We cannot state what effect this procedure would have had on the eventual recovery of the animals as none of them was observed for more than seventeen hours.

Although the results of these three groups of experiments are invalidated somewhat because of the subsequent studies, it is believed that the findings are not without significance. Using as nearly identical technic as possible in the three groups, there was no doubt but that the occlusion was tolerated better when blood was introduced into the aorta in the region of the orifice of the coronary arteries.

The results which were obtained in the fourth group of studies, in which the pulmonary artery alone was occluded, were consistently better than any others. Additional experiments, however, should be performed in which blood is introduced into the aorta during the time that the pulmonary artery is occluded and similarly during the time that the pulmonary artery and aorta are occluded, employing the technic which was used in the last group of studies. We are unable to state with certainty at the present the reasons why the results in the experiments in which the pulmonary artery alone was occluded were better than those obtained in the fifth group in which both the pulmonary artery and the aorta were constricted. It may be due to the fact that the left ventricle continues to pump the blood which was already in the lungs and which returns to the heart. This certainly results in a better blood supply to the brain than occurs when both the aorta and the pulmonary artery are occluded. We have the definite impression, without figures to support it, that the ventricles reach an absolute standstill earlier following the clamping of the pulmonary artery than when the aorta and pulmonary artery are occluded. In addition, it is believed by us that it is easier to revive a heart which has just ceased beating than it is to resuscitate one which is beating very, very feebly. Fibrillation is more liable to occur in the latter type following the use of adrenalin and massage.

A comparison of the results of the first and fifth groups of experiments, in each of which both the pulmonary artery and the aorta were occluded and no blood was introduced, is of interest. From the viewpoint of technical execution, the only differences which we know of are that a smaller opening was made in the pericardium in the fifth group and adrenalin and massage were used earlier following the

release of the occlusion. It is possible also that the massage was carried out more effectively. Pressing the heart and pericardium firmly between the hand and the anterior chest wall four or five times at intervals of several seconds seemed to be the most effective way. It is probably quite important not to make the opening in the pericardium large enough for the heart to escape through it, as marked dilatation of the heart occurs and this seems to lessen the likelihood of the return of function. The work of Gibbon and Churchill[8] does not support this conception, but the experimental conditions were somewhat different in the two groups of studies.

SUMMARY

Experiments have been performed in an effort to find a means whereby the length of time during which the vessels are occluded can be extended in the performance of the Trendelenburg operation for pulmonary embolism. The observation period following the release of the occlusion was not greater than seventeen hours in any of the studies.

The findings in the first three groups of experiments seem to warrant the following statements. A resumption of the heartbeats and respirations may take place in the dog after occlusion of the pulmonary artery and aorta for six minutes and fifteen seconds. If blood is introduced into the aorta between the clamp and the heart during the occlusion period, this time may be extended to nine minutes. The introduction of blood into the carotid as well may result in an extension of this period but the results are not clear-cut in this respect.

When the technic of the experiments was changed in that a smaller opening was made in the pericardium and adrenalin and massage were used almost immediately following the release of the constriction, it was found that occlusion of the pulmonary artery and aorta for ten minutes and thirty seconds may be recovered from. There was, however, a sustained return of the heartbeat and respirations in only four of nine experiments in which the occlusion periods ranged from five minutes and twenty seconds to ten minutes and thirty seconds.

The best results were obtained in the experiments in which the pulmonary artery alone was occluded. Recovery occurred in eleven of thirteen experiments in which the occlusion periods ranged from five to twelve minutes. The reason for this is not entirely clear. The left ventricle continues to expel, for several minutes at least, the blood which returns from the lungs. As compared with occlusion of the aorta as well as the pulmonary artery, constriction of the latter vessel alone is certainly associated with a better supply of blood to the brain and is possibly accompanied by a more adequate flow of blood to the heart muscle.

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DISCUSSION

DR. POL N. CORYLLOS.—I was more especially interested in one point of this excellent paper which referred to the fact that animals could be revived after ten to twelve minutes' complete suspension of circulation, produced by the clamping of the aorta and the pulmonary artery.

I had the opportunity lately to obtain the same results in a different way. In a series of experiments, actually under way, I have been trying to determine, in asphyxiated animals, the limits of time, after complete arrest of the heart, in which resuscitation could be obtained by direct massage of the cardiac muscle. As in Dr. Blalock's cases, during the time of cardiac arrest the animals were submitted to artificial respiration. In my experiments I have used an excellent apparatus known as the E and J Resuscitator.

In a number of these cases resuscitations were obtained within eight, ten, and eleven and one-half minutes after arrest of the heart.

In these experiments I have not yet tried to see whether these animals were liable to present any permanent nervous lesions later. They have, however, proved the point that massage of the heart can resuscitate an asphyxiated patient even eleven and one-half minutes after complete arrest of the heart, provided that during that time the blood contained in the lung had remained well oxygenated. I suppose that massage of the heart, under these conditions, pumps into the heart oxygenated blood from the lung, and passing into the coronary system renders possible the reestablishment of the cardiac action.

This point, which was corroborated by the findings of Dr. Blalock, is of importance because it shows that massage of the heart on an asphyxiated patient (anesthetic accident) not only could be attempted with all aseptic precautions, but also that it should be attempted without loss of time. The time at our disposal is sufficient for carrying out this procedure carefully and aseptically, and it can be successful provided that artificial respiration by a method permitting a good ventilation of the lung, such as mouth insufflation, intratracheal insufflation of O_2-CO_2, or even better by the use of the E and J Respirator, is not interrupted under the pretext that the suspension of circulation renders artificial respiration futile and useless.

DR. AMBROSE L. LOCKWOOD.—I feel that the extraordinary developments of thoracic surgery at the present date are something that none of us can deny, that thoracic surgery has undoubtedly developed more probably in the last ten or fifteen years than surgery of any other part of the body, and the members of this Association particularly have contributed a great deal to this development. But I am

inclined to believe that we have lagged somewhat behind in dealing with this question of pulmonary embolectomy. There have been 17 successful embolectomies, all in Europe and all on the continent. Mr. Roberts tells me this morning that they have had four additional successful cases in London in the last two years, and he is not quite sure whether those have been reported or not. If they have done nothing more, they have surely made all of us conscious of the fact that something should be done to avoid this complication, which I believe has become the major cause of death for those of us who are doing any volume of abdominal surgery. If that is the case, what are we going to do to avoid this? I think just two or three things: First we must determine some means, as near as we can, of avoiding the incidence. Second, we must recognize the early symptoms, because that is so important in avoiding what is going to be a fatal attack. We must recognize that very early elevation of temperature that comes for no other reason, apart from infection of the wound. If the wound is clear, and there is a little elevation of temperature about the sixth or seventh day, then we must guard against a thrombus. If there is a little pain or tenderness in the calf of the leg, then we must be on our guard for fear early movement on the part of the patient might excite a major attack, and I think we must come to recognize the possibility of recognizing early enough the attack that is going to be the fatal one, and I believe with close observation of these patients during attacks that we can come to the point where one can almost say certainly this is the fatal attack. If that is the case, then what are we going to do in these fatal cases?

I believe we should, in this organization, make an effort within this year or the next year in some way to obtain a mass opinion as to what we are going to do with these cases. I think in this organization the procedure which we are going to adopt ought to be worked out. Are we going to train our housemen to deal with the patient immediately the attack develops, provided he has had sufficient experience in our opinion to recognize the fatal attack? I believe we have got to come to that point of view.

DR. HOWARD LILIENTHAL.—A few months ago I sent out to all the major hospitals that had training schools for nurses a paper on this subject. It stated that it would be desirable to train our internes and even the head nurses to be embolectomy-conscious. The operating room should be ready, especially the instruments. If we have only fifteen minutes, it seems to me that there is a chance to save some of these patients.

My object in sending this reprint—it was published in the *Mt. Sinai Hospital Journal*—was so that all major hospitals with training schools should give the matter thought. The reprint was addressed to the highest medical officer of each hospital.

DR. HAROLD BRUNN.—We had the pleasure of entertaining Dr. Nyström in San Francisco during his visit and of discussing two cases which occurred in our service at the Mt. Zion Hospital a few months previously. These cases present some of the difficulties in this type of surgery which have not been stressed.

In the first case, a male, sixty-two years old, stout and plethoric, had been operated upon for a ruptured appendix. On the ninth postoperative day while on the bedpan he became suddenly dyspneic, cyanotic, and pulseless and broke out in a cold sweat. He rallied somewhat under stimulation and the oxygen tent, but he had a recurrence in about five hours. A pulmonary embolus was diagnosed. Operation was performed. Pulmonary artery was exposed and opened but no embolus was present. The patient probably died from a coronary thrombosis. The differential diagnosis of these two conditions may be very difficult.

The second case was a woman, sixty-five years old, with a massive uterine fibroid complicated with a coronary sclerosis. There was some mitral insufficiency and

edema of the ankles. At operation an aneurysm of the abdominal aorta was noted. Four days postoperative at 9:10 P.M. the patient had a sudden attack of dyspnea, air hunger, cyanosis, and perspiration. Pulmonary embolus was diagnosed.

The patient was prepared for operation and a set-up arranged, but she improved during the night and it was a question of whether this was a coronary occlusion rather than a thrombosis. Under stimulation and the oxygen tent the patient was considerably better in the morning. At this time it was our desire to do the first stage of the operation removing the ribs so that the artery could be approached immediately in case of necessity. In consultation, the medical side, however, wished to delay, believing that the patient might recover and that the first stage of the surgical procedure might be a disadvantage.

The second attack occurred about noon, and operation was immediately performed. An embolus from both the right and the left branch was removed, but the patient died during the operation.

The following is the reading of an electrocardiogram done by Dr. J. J. Sampson the morning following the first attack: Rate 99, P-R interval 0.28 seconds, latent partial A-V block; S-T interval markedly depressed in I and II. Suggests cardiac damage.

I might add that an x-ray picture was taken of the chest in the morning, but there was no change in the lung fields. It would seem probable with a pulmonary embolus occurring twelve hours before that some changes might be noted. Dr. Nyström assured me, however, that he also found that an x-ray picture of the chest is of no assistance in a differential diagnosis.

In these cases we found difficulty not only in diagnosis but also in prognosis and a difference of opinion between the medical and the surgical side as to the time for operation.

DR. ALTON OCHSNER.—Dr. Blalock referred to the prophylactic treatment of these cases. I want to mention our experience with the use of leeches in the cases of thrombophlebitis, which has been very satisfactory. Almost invariably a patient with considerable febrile reaction and a great deal of pain can be relieved within an hour's time by the application of leeches. The pain will disappear within six to eight hours, the redness will disappear, and usually within twenty-four hours the temperature is normal. Whether we have prevented pulmonary complications, of course, it is impossible to say, but we do feel that we have shortened the convalescence of these patients with thrombophlebitis and that possibly the incidence of pulmonary embolism has been decreased.

DR. HARRY BALLON.—I should like to ask whether any histologic studies were made of the animals' brains, and, if they were, whether Dr. Blalock would care to comment particularly upon those animals which received injections of blood into the carotid artery. Supplying "nutrition" to the brain during the period of cardiac arrest seems to me an important consideration. A question which has often arisen in my mind and I am sure in the minds of others is, Is cardiac arrest of more than five minutes followed by irreparable damage to the brain? Without attempting to draw too much clinical application from Dr. Blalock's paper, it is nevertheless well to consider how intelligent an individual brought back to life under such circumstances is likely to be.

DR. RICHARD H. OVERHOLT.—We have a team prepared to do these operations. In two instances the patient was taken to the operating room and watched during what was supposed to be a fatal attack and both patients recovered. A third patient was taken to the operating room. In this particular case apparently small emboli were being thrown previously and an x-ray picture showed clouding of the right lung. I was called to see this patient at the time of the apparently

fatal attack. The pulse was between 180 and 200. He had pain in the chest and showed marked cyanosis. I felt that we might experiment in this particular case and give a pneumothorax; that if a sudden mechanical change in the chest had occurred on one side only, a sudden collapse of that lung might correct the situation. We hurriedly took an x-ray picture and an electrocardiogram. I then slowly gave a pneumothorax on the side of the suspected embolism. Immediately the patient's pulse returned to normal. We had an electrocardiographic tracing. The cardiologist of the clinic has gone over this, and he is not sure that the attack was due solely to the embolus. It may have been some peculiar cardiac irregularity.

I wanted to bring up the possibility of treating embolism, if we can decide which side it is on, by giving pneumothorax on the affected side. This might correct a mechanical change in the chest which must occur with a sudden occlusion of one of the pulmonary arteries.

DR. OWEN H. WANGENSTEEN.—I should like to make one remark relative to the prophylaxis of pulmonary embolism. In 1899, Lennander, Professor of Surgery at Uppsala, advised placing patients after operation in slight Trendelenburg position with legs and feet elevated and the head and body on a lower plane, to preclude, as far as the employment of gravity would permit, venous stasis in the veins of the pelvis and the lower extremities. Lennander further suggested that patients after abdominal operations should have their position in bed changed frequently and should be turned from side to side; in addition, he advised the application of massage to the lower extremities and the use of passive exercises.

Of the large number of therapeutic expedients which have been suggested as being of value in obviating the occurrence of postoperative pulmonary embolism, the measure of *frequent active* movements on the part of the patient, I believe, has the best rationale. I find myself and other members of our professional and nursing staff enjoining upon our patients after abdominal operations, early in their convalescence, many times a day, the necessity of exercising their legs and arms frequently and moving about in bed as much as they can without discomfort. Active movement on the part of the patient is superior to passive motions practiced by Lennander. Frequent change of position, a principle recognized by all orthopedic surgeons, is also an important item. Our patients for several days after abdominal operations have their positions changed every two hours day and night unless they are asleep. From the time that the patient has fully awakened from the anesthesia, until he can move about in bed freely of his own accord, he lies on his back two hours; then on his right side for two hours; on his back again for two hours; and then on his left side for two hours and two hours on his back again and so on, spending half of the time on his back, and the other half divided between the right and the left lateral positions.

In this connection, it is not without interest that the incidence of embolism after surgery upon the same organ, by different means of approach, may vary considerably: for example, the operations upon the prostate gland. The incidence of embolism following the suprapubic operation, I believe, is much greater than that which accompanies the perineal operation, or transurethral prostatic resection. The period of disability of the patient is also greater following the operation upon the abdominal wall. Similarly, a temporary reflex inhibition of movement of the diaphragm, usually of forty-eight to seventy-two hours' duration, attends any operation of magnitude upon the abdomen which is absent in the others. The disability afforded patients after abdominal operations in moving about freely undoubtedly is an important factor in causing venous stasis and thrombosis. At the University Hospital, where we have tried to counteract some of these effects of abdominal operations by encouraging active motion, my colleagues and I have the definite impression that frequent change of position and active exercise of the

extremities on the part of the patient constitute an important therapeutic agency in the prophylaxis of pulmonary embolism.

DR. ALFRED BLALOCK.—In reply to Dr. Coryllos, artificial respiration was used.

I agree with Dr. Lockwood that the important thing on which we should focus our attention is prevention.

I may not have understood Dr. Lilienthal, but if I did, I disagree with him as to the part which the house staff should take in this procedure. It is quite important that a hospital staff be prepared to carry out such an operation, but, when mistakes in diagnoses are made by experienced surgeons, I think it is too great a responsibility at the present stage for the final opinion to be made by the house staff, and I think that the operation will be placed in even greater disrepute than at the present time if such a plan is carried out.

Dr. Ochsner's observations on the use of leeches are extremely interesting.

In regard to Dr. Ballon's question, no histologic studies have been made. As I stated, we have just begun to determine whether or not an ultimate recovery of animals will take place.

As regards Dr. Overholt's remarks, it is difficult for me to conceive of the induction of pneumothorax as being of much aid in the treatment of an embolism of one of the two pulmonary arteries. It is well known that one of the two branches, either right or left, can be occluded, and still have the patient survive, at least for a long while.

In closing, I would say that no clinical deductions are drawn from these experiments, but it seems likely that the chances of recovery of the patient will be better if one occludes the pulmonary artery alone during the performance of the embolectomy rather than carrying out the usual Trendelenburg procedure of occlusion of both the pulmonary artery and the aorta.

EWING'S TUMOR OF THE RIB*

Report of Two Cases

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INCREASING examples of the condition known as Ewing's tumor contribute to the knowledge of the pathology and symptomatology of this neoplasm, which has been designated extraosseous in etiology. Since it is a condition occurring most often outside the thorax, a description of two case histories of patients with Ewing's sarcoma is offered; as in both these patients the tumor originated in the ribs.

Case 1.—Patient, F. W., aged ten years, white, male, had a relatively slight trauma to the left side of his chest in the early part of May, 1933. He was taken to a local pediatrician because of soreness in the left axilla. His physician could then determine no underlying pulmonary pathologic condition, and diagnosed the case as a simple contusion. The boy was then afebrile, up and about. The pediatrician saw him two or three times subsequently during the month of May and did not alter his original diagnosis. Early in June, Dr. C. F. Roche (Miami, Fla.) was called to see the patient and diagnosed a pleural effusion in the left chest. The patient's temperature then varied between 101° and 102° F. The only symptoms were pain, which was not related to breathing movements, and slight anorexia. The pain was worse at night. Roentgenogram confirmed the diagnosis of pleural effusion. On June 23, 100 c.c. of bloody fluid was aspirated, which contained no microorganisms, and the various media inoculated with it remained sterile. Two guinea pigs were inoculated intraperitoneally. At autopsy, six weeks later, no evidence of tuberculosis existed in the pigs. Following the aspiration the patient's temperature decreased and did not exceed 100° for almost three weeks. He was comfortable until July 12, when again the signs of fluid increased, as did his temperature. Two days later an additional 250 c.c. of bloody fluid was aspirated. Culture media inoculated remained negative, and the two animals inoculated offered no evidence of tuberculosis. The blood picture on June 23 was as follows: hemoglobin (Sahli) 98 per cent; erythrocytes 4,920,000; leucocytes 14,900; neutrophile granulocytes 67 per cent; small lymphocytes 24 per cent; large lymphocytes 5 per cent; large mononuclears 4 per cent. On July 1 the leucocytes numbered 8,950, and the differential count gave figures within the normal. On July 24, the time of the second aspiration, the total leucocyte count was 23,150, neutrophile granulocytes 65 per cent. The child's temperature then was 101°. The uterine examination throughout the illness was normal except in a few instances in which a slight trace of albumin and a few hyaline casts were found.

On infrequent occasions there were transient aches and stiffness of joints with no redness, swelling, or local heat demonstrable. Salicylates made the child comfortable, but ultimately their oral use produced nausea, although nausea had been observed without salicylates.

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On August 8 evidence of reaccumulation of fluid was again found. The temperature was increased, and pain in the left chest and in both shoulders appeared. On that day his blood count was: erythrocytes 4,300,000; hemoglobin 87 per cent; leucocytes 13,675; neutrophile granulocytes 58 per cent, of which 31 per cent were segmented and 27 per cent were stab cells; lymphocytes 41 per cent; large mononuclears 1 per cent.

Cough, profuse night sweats, and hemoptysis were never observed. The appetite was continuously fair, and the patient did not lose much in weight. The apices were always clear on physical and x-ray examination. The child was constipated. Spleen and liver were not palpable.

The early suspicion of tuberculosis was abandoned, and malignancy was considered. The patient was referred to Dr. Ringer of Asheville, who saw him on August 16. Examination revealed an increase in fluid within the left pleural space up to the clavicle. Seven hundred and fifty c.c. clear fluid was aspirated, and 500 c.c. air was substituted. The roentgenogram disclosed a moth-eaten condition of the middle third of the shaft of the sixth rib. The intercostal spaces above and below that rib were much wider than any of the others. Below the rib an ill-defined area of increased density was seen in the pleura. This area suggested the existence of a mass. The radiologist, Dr. Murphy, in consultation with Dr. Ringer, offered the opinion that this tumor mass originated in the rib and the condition was that of Ewing's tumor.

On August 25 the patient was admitted to the hospital. At that time the child was emaciated; the heart rate was rapid, rhythm regular; no murmurs were present and the muscle sounds were weak. The organ was pushed to the right side; there was a definite mediastinal shift; the apex beat was at the right of the sternum. The abdomen was slightly distended, liver not enlarged, spleen pushed down but not enlarged. Rectal examination was negative. Blood pressure was 110/70 mm.

Examination of the posterior aspect of the thorax showed a definite tumor mass slightly posterior to the midaxillary line and running around the sixth rib toward the spine. The tumor was not movable and seemed definitely to be a tumor of that rib.

The diagnosis of osteomyelitis or neoplasm of that rib was made.

Under gas anesthesia an incision was made over the tumor mass along the line of the sixth rib. The dissection was carried down to the rib, which was found to be necrotic and very much enlarged. On reflection of the periosteum and removal of the rib, pus escaped from beneath its bed. The moth-eaten appearance and necrosis existed from the axillary line to the angle of the rib. The rib was resected and the pleural cavity was not opened. The bed of the rib was packed with irradiated vaseline gauze. The patient reacted well to the operation but his condition remained critical. The temperature remained high and the patient was toxic. Glucose in Ringer's solution was given intravenously in quantity every second day, and blood transfusions of 350 c.c. were given on the alternate days. This procedure was continued for nearly three weeks following operation without the patient's condition being appreciably changed. On the third day after operation 150 c.c. bloody fluid was aspirated from the left pleural space. On the fourth day 600 c.c. of fluid was removed. This was flocculent and found to contain large numbers of red blood cells and pus cells. The leucocyte count was over 28,650, with 50 per cent myelocytes, 24 per cent neutrophile granulocytes, 8 per cent lymphocytes, and 18 per cent monocytes.

On account of marked mediastinal shift with increased evidence of fluid in the left chest, seven days after the removal of the rib a closed thoracotomy was done; 1,550 c.c. of bloody flocculent fluid were evacuated in the first twenty-four hours.

From this time until death the discharge from the pleural cavity averaged 400 c.c. every twenty-four hours.

The diagnosis now was definitely that of Ewing's sarcoma; although there was a disagreement among the various pathologists for a short time. One opinion offered the diagnosis of osteomyelitis, as the slide contained numerous pus cells and cocci; in fact, a streptococcus infection did accompany the neoplasm. Another opinion was that of neuroblastoma. With interchange of slides, however, finally the pathologic diagnosis was unanimously Ewing's sarcoma. Deep x-ray treatment was given on September 13, 15, and 18, after which time these treatments were abandoned because of the gravity of the patient's general condition. The patient died September 26, 1933.

CASE 2.—Patient, H. R. C., twenty years old, white, lumberman, complained of pain in the left arm and swelling in the left axilla. He claimed that the pain was constant and was worse at night. He had been treated for rheumatism. During the last week of March, 1935, he called on Dr. Stringfield, who referred him to me. I saw him April 4. This young man claimed he had always been reasonably healthy. He had had chickenpox, whooping cough, measles, and mumps during childhood and adolescence. He had influenza at the age of eighteen and again a year later. The first time he called for medical attention was six and one-half years ago when he fell from a form twelve feet high, struck his left side, cutting his left hand and his chin. He does not remember whether there was any injury to the rib, or whether he struck it at all. He soon recovered and worked continuously until three months ago.

About Christmas time, 1934, he developed a severe cough and high temperature. These symptoms lasted for two weeks. The middle of January his left arm began to hurt and also his right leg. He could not use his left arm and could not walk well. One morning in the early part of February he suddenly discovered a lump the size of a walnut in the left axilla. This lump continued to increase in size and was apparently the cause of severe pain throughout the left arm. He also had pain in both hips and throughout the lower extremities, the latter interfering with walking. There were no swellings in neck or in groins. The pain now was constant and worse at night. His temperature reached 101° to 102° F., and he had night sweats. There were no headaches or pulmonary symptoms, although he stated he had had a backache for the last eight days. His appetite was poor, and he had lost twenty-five pounds in weight; his former weight had been 153 pounds. He also complained of urinary disturbance and dryness of throat, attributing these last two symptoms to some medication he obtained from a physician. He was constipated; there was no complaint of indigestion. He grew very nervous and slept poorly on account of pain. The larynx appeared to be normal, the tonsils quite large, particularly the left one, and the turbinates were increased in size. The ears were normal.

His family history is unimportant as far as neoplastic disease is concerned. His habits are normal. Blood pressure was 86/58 mm. Repeated sputum examinations for tubercle bacilli were negative. All tests for syphilis were negative. The urine contained a slight amount of albumin, abundant indican, otherwise it was negative. Feces contained many eggs of Ascarus lumbricoides. The blood count at that time was: erythrocytes 3,581,000; leucocytes 10,200; hemoglobin 49 per cent (7.8 gm.); neutrophile granulocytes 63 per cent; basophiles 1 per cent; lymphocyes 32.5 per cent; monocytes 3.5 per cent; monocytes 3.5 per cent. A clinical diagnosis of Ewing's tumor was made. A roentgenogram showed marked erosion of the third rib and a tumor of the left axilla extending into thoracic cavity. There was no demonstrable pathologic condition of the pelvis, the spine, or either femur. The diagnosis by the roentgenologist also suggested Ewing's sarcoma. A metastatic lesion was shown in the right lung.

The patient was admitted to the Mission Hospital April 8 for operation to determine the nature of the tumor. The tumor mass was incised and a portion of the third rib removed. The pathologist diagnosed the condition as Ewing's sarcoma. On April 11, 13, 17, and 22 the patient was exposed to deep roentgen therapy during which time the tumor receded 75 per cent, but the general condition improved in no way. The prognosis remained bad, and roentgen (deep) therapy had to be discontinued. The last report was that the patient was dying.

The two case histories have a certain analogy. There are, however, points in which the histories differ. In the first case, trauma was a recent factor. In the second case, the tumor appeared years later, although there was no history of injury to the rib.

Both patients had pain, intermittent, gradually increasing, but finally it became a permanent symptom—worse at night. This is a classic picture.

Both patients had fever, and the range is also classic. The case with suppuration had a higher degree of fever than the one without such manifestation.

Differential diagnosis: Myeloma is rare in children; lymphosarcoma may occur. Rheumatism and neuritis are often diagnosed without investigation of the condition. In many diagnoses of neuritis in the young, osteosarcoma is found upon close examination. Osteomyelitis in the rib with demonstrable mass is most likely Ewing's tumor. On the other hand, Garre's chronic osteomyelitis as seen on roentgenographic examination in the long bones can be mistaken for early Ewing's tumor. The pain in these children (Garre) subsides spontaneously and more rapidly after a single dose of deep x-ray therapy (Murphy's case in Chicago reported before the American Association for the Study Neoplastic Disease, also Bloodgood's case reported at the same meeting, September, 1934; Washington, D. C.). Garre's osteomyelitis subsides, and Ewing's tumor is recurrent—this is a differential diagnosis in which the element of time is of importance.

There are adrenal tumors which give rise to secondary growths of ribs, spine and long bones, liver and other organs. These occur in infants, and the histologic picture may resemble Ewing's sarcoma to some extent. As a matter of fact, the tumor may occur between the age of three months and ten years. These tumors are known as adrenal neurocytomas, and follow trauma or occur spontaneously. There is ecchymosis of one or both eyelids, soon followed by exophthalmos, a tumor of the orbit and temporal region with extension to the articular and submaxillary nodes. The orbital tumor reaches large dimensions, while the abdominal tumor is discovered only at autopsy. The adrenal growth may be as large as a walnut or a child's head.

Congenital adrenal sarcoma in the left adrenal gland gives rise to metastases of ribs and cranium. The symptoms are those of a rapidly

enlarging abdominal tumor. (This is known as Pepper's type of adrenal sarcoma.)

Roentgen findings: Ewing's tumor does not occur near the epiphyses, but rather in the shaft. It does not invade the medulla but it involves the cortex and the periosteum. There is no formation of an involucrum as in osteomyelitis. The lesions are not multiple as in myeloma. One rib only is involved. Metastasis is not to other ribs.

Blood findings: A mild increase in leucocytes is usually observed. While the average count varies from 10,000 to 16,000 (high counts), a figure of 20,000 or more is also encountered. This depends apparently upon such complications as were seen in the first patient. It is readily seen why diagnoses of osteomyelitis or pleuritis are offered in the presence of such high count. Empyema may also be considered. The diagnosis may not be facilitated when the fluid from the cavity contains microorganisms. Neither is the presence of blood in the pleural fluid a guide, as in our experience pleural fluid containing blood is by no means unusual in tuberculous pleurisy.

The erythrocyte and hemoglobin values are normal in the early uncomplicated form of Ewing's sarcoma. As the disease advances, these values lessen, and, in a sense, the low values represent a prognostic aid.

The differential count is of interest so far as there is apparently no relation between the leucocyte value and that of the neutrophile granulocytes, at least not in the manner known to be in acute empyema, acute osteomyelitis, or acute appendicitis. With these conditions the total neutrophilic granulocytes may be present from 76 to 92 per cent or more with a mean average of 82 per cent. Apparently such figures are not reached with Ewing's sarcoma even though the total leucocyte count is beyond 20,000. The appearance of the myelocytes is of significance, as it apparently denotes the approaching end.

The blood pressure findings are not decisive for the purpose of differential diagnosis. In fact, low blood pressure may be interpreted as evidence favoring adrenal disease when such is not present. In the second case here reported the blood pressure was comparatively low, yet the patient's age in a way would indicate against adrenal neurocytoma or sarcoma. Far-advanced Ewing's sarcoma with asthenia can be associated with low blood pressure.

DISCUSSION

DR. ALFRED BLALOCK.—Since this is a rather rare lesion of ribs, I should like to speak briefly of two additional cases which I have had. One of these was a boy twenty years old who came under observation three years ago.

(Slide) This is a specimen that was removed from this patient.

(Slide) Portions of the seventh, eighth, and ninth ribs including the tumor are shown. This tumor also involved the diaphragm; at least it was necessary

to cut away part of the diaphragm in removing it, and the diaphragm was transplanted up to the sixth rib.

As I stated, that operation was performed three years ago. This boy as yet has no evidence of metastasis and appears to be quite all right.

The second patient was a boy of nineteen years. This tumor involved the twelfth rib and several of the transverse processes. He was operated upon two years ago and at the present time is still alive, but he does have metastases.

DR. W. P. HERBERT.—There is very little more that I have to add. I should like to know from Dr. Blalock whether there was any history of trauma in his two cases. Trauma is unquestionably a factor in these cases. The first patient had a definite trauma, and the pathologic condition appeared shortly afterward. In the second case there was a six-year period between the trauma and any evidence of the beginning of the tumor.

These cases are something that I believe we should look for, in view of the fact that this first case, because of the involvement of the pleura, and the pleural fluid, was diagnosed as tuberculosis, then as osteomyelitis. Of course, osteomyelitis is the thing most difficult to differentiate from Ewing's sarcoma. Especially is this true if there is a superimposed infection, as there was in the first case, a streptococcic culture being obtained late in the disease.

STUDIES ON THE VOLUME OUTPUT OF BLOOD FROM THE HEART IN ANESTHETIZED DOGS BEFORE THORACOTOMY AND AFTER THORACOTOMY AND INTERMITTENT OR CONTINUOUS INFLATION OF THE LUNGS*

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INTRODUCTION

THE experiments which are described in this report comprise a study of the blood output of the heart in anesthetized dogs, first during natural breathing and then after wide-open thoracotomy and intratracheal insufflation of the lungs. They were planned to simulate conditions which exist during major intrathoracic operations, when wide-open thoracotomy is necessary for exposure and the consequent loss of intrapleural negative pressure necessitates positive inflation of the lungs. Conditions such as these are met with during such operations as lobectomy, pneumonectomy, esophagectomy, and the removal of mediastinal tumors. All of these procedures seriously alter the pressure relationships within the chest and are associated with a high mortality. The increasing frequency with which they are being performed, therefore, makes it important to know in what manner the circulation is affected.

It is generally believed that the subatmospheric pressure which normally prevails in the thoracic cavity has an important influence in promoting the circulation by sucking the venous blood into the chest and in this manner maintaining the filling of the heart. If this is true, a complete obliteration or any loss of the negative pressure should result in an impaired filling of the heart, which in turn should be reflected in a decrease in the cardiac output. Coincident with thoracotomy and the loss of intrathoracic "negative" pressure, when expansion of the lungs is maintained by increasing the intratracheal pressure, an extra burden is put on the heart because resistance is introduced to the passage of blood through the lungs. It has been stated that intermittent inflation is more desirable than continuous, on the theory that the alternate expansion and collapse of the lungs acts like a pump and propels the blood.[1]

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It occurred to us that it would be profitable to study the circulation in animals under these conditions and to measure the effects of intermittent and continuous inflation. As a measure of the circulation we elected to study cardiac output because in the presence of a normal heart it is perhaps the most accurate indication of circulatory efficiency and can be determined easily in an anesthetized dog. The significance of our observations is discussed in relation to thoracic opera-

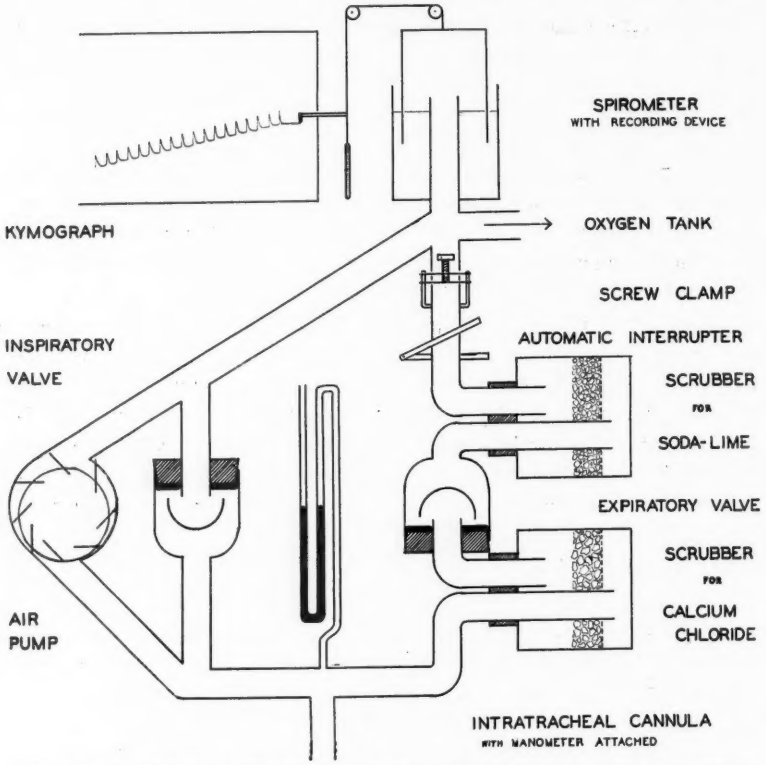

Fig. 1.—A diagram of the apparatus used. Inspiration may take place either through the valve or by means of the pump; partial occlusion of the expiratory airway with screw clamp or automatic interrupter, with the pump going, causes continuous or intermittent elevation of intratracheal pressure.

tions and the several procedures that are used by anesthetists for maintaining ventilation when the chest is open.

METHOD

Dogs which had been anesthetized by the intravenous injection of barbital sodium (30 mg. per kilo body weight) were used in all the experiments. By means of a specially constructed T-shaped tracheal cannula the dogs breathed oxygen from a closed respiratory system consisting essentially of inspiratory and expiratory mercury seal valves,[2] a soda lime scrubber for removal of carbon dioxide, and a Benedict

spirometer with a recording pen for measurement of the oxygen absorption. An electrically driven oil-sealed air pump was connected in parallel arrangement with the inspiratory valve, so that the dog could either inspire through the valve or be ventilated by the pump. A scrubber containing calcium chloride was also inserted in the expiratory side in order to avoid condensation of moisture in the mercury seal valve. Finally, a screw clamp and an automatic interrupter were placed on the expiratory tube; these, by causing an obstruction in the air circuit when the pump was running, produced an easily controlled rise in intratracheal pressure, either intermittent or continuous, which was measured by a mercury manometer connected directly with the tracheal cannula (Fig. 1).

When anesthesia was complete, the trachea was opened and the cannula inserted, connecting the dog with the closed respiratory system. While kymographic tracings were being obtained, samples of arterial and mixed venous bloods were taken, the former through a cannula inserted in the femoral artery and the latter by means of a special cannula[3] introduced into the right heart through a slit in the external jugular vein. The oxygen contents of the blood samples were estimated according to the manometric method of Van Slyke and Neill[4] and the cardiac output calculated by the Fick formula:[5]

$$\frac{\text{c.c. of oxygen absorbed per minute}}{\text{oxygen absorbed by 1 c.c. of blood passing through the lungs}} = \text{c.c. of blood passing through the lungs per minute}$$

First, control studies were obtained with the animals breathing naturally. Then, after intermittent inflation of the lungs had been begun, the chest was opened by dividing the sternum in the midline and the ribs were held wide apart with a self-retaining retractor. This eliminated the effect of respiratory motions on the expansion of the lungs, and subjected not only the lungs but also the pericardium and great vessels to atmospheric pressure.* Another set of observations was made after a short period of intermittent inflation; then the lungs were inflated continuously and the observations repeated; finally, the chest was closed, the animal was allowed to breathe naturally again, and, after a period of time, the studies were again repeated. In some instances additional periods of intermittent inflation were studied before closing the chest, and in some the final period was omitted.

RESULTS

The Effects of Thoracotomy and Intermittent or Continuous Inflation (Table I; Figs. 2 and 3).—These effects were studied in eight animals. Intermittent inflation was begun just before the pleura was opened, and the estimations of cardiac output were made immediately thereafter. In every instance there was a significant decrease in cardiac output. This varied between 45.9 and 81.5 per cent and averaged 60.1 per cent. In all of these experiments the intratracheal pressure was deliberately kept low to avoid the introduction of any unnecessary pressure on the pulmonary capillaries and to prevent the escape of oxygen through the pleura. It was found that the lungs could be maintained in what appeared to be an average degree of expansion by pressures that ranged from 4 mm. of mercury at the end of expiration to 8 mm. of mercury at the end of inspiration, and the pressures

*Under these circumstances it was found essential to avoid high intratracheal pressures in order to prevent loss of oxygen through the pleural surface.

TABLE I

THE EFFECTS OF THORACOTOMY AND INTERMITTENT OR CONTINUOUS INFLATION

	SUMMARY OF EXPERIMENTAL DATA	CONTROL PERIOD CHEST CLOSED	INTERMITTENT INFLATION CHEST OPEN	CONTINUOUS INFLATION CHEST OPEN	INTERMITTENT INFLATION CHEST OPEN	SECOND CONTROL CHEST CLOSED
Experiment 100	Intratracheal pressure (mm. mercury)		5	6	6	
Dec. 28, 1934	Pulse rate	176	160	165	160	
Weight 12.1 kg.	Oxygen content of arterial blood (per cent by volume)	14.0	13.2	14.4	14.0	
Female	Oxygen content of venous blood (per cent by volume)	10.4	3.9	9.3	6.5	
Barb. sod. 3.6 gm.	Arteriovenous oxygen difference	3.6	9.3	5.1	7.5	
	Oxygen absorbed (c.c. per minute)	94.7	82.5	69.9	86.8	
	Volume output of blood from the heart (c.c. per minute)	2632	887	1372	1157	
	Decrease in cardiac output (per cent)		*66.3*	*47.8*	*56.0*	
Experiment 102	Intratracheal pressure (mm. mercury)		6-7	8	7-8	
Jan. 16, 1935	Pulse rate	176	156	146	120	
Weight 17.3 kg.	Oxygen content of arterial blood (per cent by volume)	21.0	22.0	21.4	22.6	
Male	Oxygen content of venous blood (per cent by volume)	17.3	13.3	15.2	10.3	
Barb. sod. 5.2 gm.	Arteriovenous oxygen difference	3.7	8.7	6.2	12.3	
	Oxygen absorbed (c.c. per minute)	119.2	129.2	85.0	97.3	
	Volume output of blood from the heart (c.c. per minute)	3221	1485	1371	791	
	Decrease in cardiac output (per cent)		*53.9*	*57.4*	*75.5*	
Experiment 104	Intratracheal pressure (mm. mercury)		4-8	4	4-6	
Feb. 6, 1935	Pulse rate	164	144	130	130	150
Weight 12.6 kg.	Oxygen content of arterial blood (per cent by volume)	17.0	17.8	18.8	18.6	18.3
Female	Oxygen content of venous blood (per cent by volume)	13.9	11.3	10.4	10.8	12.6
Barb. sod. 3.8 gm.	Arteriovenous oxygen difference	3.1	6.5	8.4	7.8	5.7
	Oxygen absorbed (c.c. per minute)	59.9	60.9	54.1	68.4	72.4
	Volume output of blood from the heart (c.c. per minute)	1934	938	644	877	1270
	Decrease in cardiac output (per cent)		*51.5*	*66.7*	*54.6*	*34.3*

TABLE I—CONT'D

	SUMMARY OF EXPERIMENTAL DATA	CONTROL PERIOD CHEST CLOSED	INTERMITTENT INFLATION CHEST OPEN	CONTINUOUS INFLATION CHEST OPEN	INTERMITTENT INFLATION CHEST OPEN	SECOND CONTROL CHEST CLOSED
Experiment 105	Intratracheal pressure (mm. mercury)		6-7	3		
Feb. 13, 1935	Pulse rate	140	120	128		140
Weight 13.5 kg.	Oxygen content of arterial blood (per cent by volume)	18.0	17.5	19.2		19.4
Male	Oxygen content of venous blood (per cent by volume)	15.9	8.4	11.4		15.7
Barb. sod. 4.1 gm.	Arteriovenous oxygen difference	2.1	9.1	7.8		3.7
	Oxygen absorbed (c.c. per minute)	65.3	52.4	52.2		61.6
	Volume output of blood from the heart (c.c. per minute)	3110	576	669		1664
	Decrease in cardiac output (per cent)		*81.5*	*78.5*		*46.5*
Experiment 106	Intratracheal pressure (mm. mercury)		4-5	4		
Feb. 20, 1935	Pulse rate	130	128	108		100
Weight 13.3 kg.	Oxygen content of arterial blood (per cent by volume)	18.7	18.6	20.7		19.5
Male	Oxygen content of venous blood (per cent by volume)	16.4	13.4	15.4		16.1
Barb. sod. 4.0 gm.	Arteriovenous oxygen difference	2.3	5.2	5.8		3.4
	Oxygen absorbed (c.c. per minute)	72.9	58.5	58.7		54.0
	Volume output of blood from the heart (c.c. per minute)	3168	1126	1107		1588
	Decrease in cardiac output (per cent)		*64.4*	*65.0*		*49.9*
Experiment 107	Intratracheal pressure (mm. mercury)		5-7	3	4-5	
Mar. 20, 1935	Pulse rate	140	152	140	162	160
Weight 15.8 kg.	Oxygen content of arterial blood (per cent by volume)	21.7	22.0	23.0	23.7	24.1
Male	Oxygen content of venous blood (per cent by volume)	20.2	16.2	18.2	14.7	4.7
Barb. sod. 4.7 gm.	Arteriovenous oxygen difference	1.5	5.8	4.8	9.0	9.4
	Oxygen absorbed (c.c. per minute)	86.7	91.7	74.7	90.6	75.0
	Volume output of blood from the heart (c.c. per minute)	5781	1581	1557	1006	797
	Decrease in cardiac output (per cent)		*72.7*	*73.1*	*82.6*	*86.2*

TABLE I—CONT'D

	SUMMARY OF EXPERIMENTAL DATA	CONTROL PERIOD CHEST CLOSED	INTERMITTENT INFLATION CHEST OPEN	CONTINUOUS INFLATION CHEST OPEN	INTERMITTENT INFLATION CHEST OPEN	SECOND CONTROL CHEST CLOSED
Experiment 109	Intratracheal pressure (mm. mercury)		4-5	3		
Apr. 3, 1935	Pulse rate	136	140	144		134
Weight 11.5 kg.	Oxygen content of arterial blood (per cent by volume)	16.6	19.1	19.7		19.1
Male	Oxygen content of venous blood (per cent by volume)	13.9	12.1	12.7		11.1
Barb. sod. 3.4 gm.	Arteriovenous oxygen difference	2.7	7.0	7.0		8.0
	Oxygen absorbed (c.c. per minute)	70.6	99.0	93.0		65.6
	Volume output of blood from the heart (c.c. per minute)	2617	1414	1328		820
	Decrease in cardiac output (per cent)		*45.9*	*49.2*		*68.6*
Experiment 110	Intratracheal pressure (mm. mercury)		4-5	3		
Apr. 10, 1935	Pulse rate	128	128	130		144
Weight 12.1 kg.	Oxygen content of arterial blood (per cent by volume)	17.3	17.6	18.6		18.5
Male	Oxygen content of venous blood (per cent by volume)	14.1	11.4	14.3		12.5
Barb. sod. 3.6 gm.	Arteriovenous oxygen difference	3.2	6.2	4.3		6.0
	Oxygen absorbed (c.c. per minute)	75.2	70.5	89.9		80.5
	Volume output of blood from the heart (c.c. per minute)	2350	1138	2090		1342
	Decrease in cardiac output (per cent)		*51.5*	*11.1*		*42.9*

used varied between these two extremes. The apparatus which was used made it necessary to increase the respiratory rate considerably above the control level in order to keep the intratracheal pressures as low as this. An increase in the minute volume of ventilation, therefore, was present in this period.

When inflation was then changed from intermittent to continuous, no great difference in cardiac output occurred. In five experiments

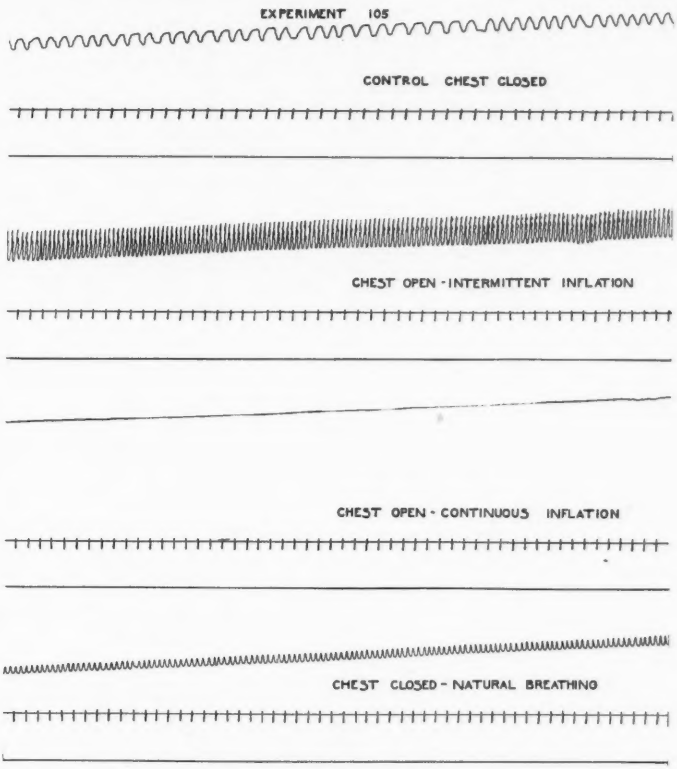
EXPERIMENT 105
CONTROL CHEST CLOSED
CHEST OPEN - INTERMITTENT INFLATION
CHEST OPEN - CONTINUOUS INFLATION
CHEST CLOSED - NATURAL BREATHING

Fig. 2.—The kymographic tracings obtained in a typical experiment, showing the relative hyperventilation during intermittent inflation, the complete absence of lung motion with unchanged oxygen absorption during continuous inflation, and the return to natural breathing after closure of the chest.

(Nos. 102, 105, 106, 107, and 109) the change was negligible. In two (Nos. 100 and 110) the cardiac output increased, and in one (No. 104) it decreased still further. The average decrease from the control in this period was 56.1 per cent, compared to 60.1 per cent in the preceding period. The intratracheal pressures during this period were regulated to keep the lungs in the position of slight inflation and varied from 3 mm. to 8 mm. of mercury, the average being 4 mm. of mercury.

In most of the experiments the animals made no respiratory effort, due probably to the hyperventilation of the preceding period. In a few instances in which respiratory effort occurred the wide-open thoracotomy made its effect on lung expansion negligible.

Studies were made during a second period of intermittent inflation (using pressures equal in magnitude to those that had been used in the first) in four of the eight animals (Nos. 100, 102, 104, and 107). In two experiments (Nos. 102 and 107) the reduced output, which had

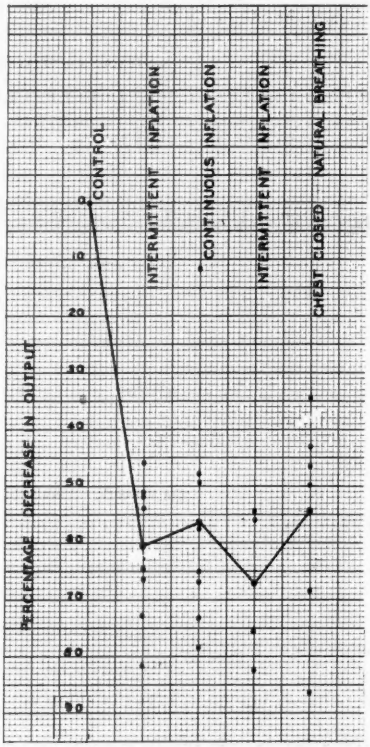

Fig. 3.—Graph showing percentage decreases in cardiac output during the various periods with the averages united by a line.

been essentially the same during the previous two periods, fell still further. In one experiment (No. 100), in which the output had increased significantly during continuous inflation, it also fell, but not to the same degree. In the fourth experiment (No. 104), in which the output had fallen during the period of continuous inflation, there was an increase.

In the six animals in which the observations were repeated after the chest was closed and natural breathing resumed, the results were

somewhat variable. In no instance was the cardiac output completely restored to the control figure, but in three experiments (Nos. 104, 105, and 106) the output was considerably greater than in any of the periods while the chest was open; in one experiment (No. 110) the output was greater than in the period of intermittent inflation, but less than during continuous inflation; in the remaining two experiments (Nos. 107 and 109) the output was less than when the chest was open. The average decrease from the control in this period was 54.7 per cent, not significantly different from that during continuous inflation in which it was 56.1 per cent.

COMMENT

The pronounced decrease in the volume output of the heart which was observed in all of these experiments after thoracotomy and positive inflation of the lungs was probably due to the altered pressure relationships which accompanied these procedures.* In a closed chest the heart and lungs are surrounded by a subatmospheric pressure which is generally believed to draw blood into the large venous trunks and in this way promote the venous return to the heart. When the chest was opened wide, as it was in our experiments, the heart and lungs were exposed to atmospheric pressure, and this aspirating or sucking effect was completely lost. This loss was probably responsible in large measure for the decrease in cardiac output which was observed.

Theoretically, one can separate the effects of intrapericardial pressure from those of intrapleural pressure, but this does not apply in our experiments. The "negative" intrapericardial pressure in a closed chest depends on the same forces that are responsible for the "negative" intrapleural pressure, and when these forces are eliminated both pressures are destroyed. On the contrary, the intrapericardial pressure can be varied without destroying the intrapleural "negative" pressure, and Beck and Cox,[6] Beck and Isaac,[7] and Blalock[8] have measured cardiac output in dogs under these conditions. After pericardiostomy Beck and his associates observed decreases varying between 15 and 36 per cent, with some restoration of the decrease following closure of the pericardial opening. Blalock, on the other hand, found that the changes in the output of the heart after pericardiostomy were not marked, slight decreases in some of his experiments being balanced by comparable increases in others. The greater and more consistent decreases observed by us after thoracotomy were due presumably to the fact that all of the chest contents were exposed to atmospheric pressure.

Our experimental studies, then, support the belief that the closed chest is important for maintaining the circulation. This was one of

*It seems unlikely that operative trauma alone was responsible for the decrease in cardiac output because: (1) the decrease was not progressive, and (2) closure of the chest was followed by partial restoration in half of the animals.

the reasons why Sauerbruch[9, 10] introduced the negative pressure chamber for operations within the thorax. In preliminary experiments on animals, ventilated by the positive pressure method, he observed an increase in venous pressure when the chest was opened. This effect was not observed if the animal was first placed in the negative pressure chamber. He[11] demonstrated also an increase in the pressure in the femoral veins of dogs after the production of a unilateral open pneumothorax and was of the opinion that the right heart, as a consequence, received less blood and therefore with each systole projected less into the lungs.

The negative pressure chamber, however, lasted only a short time. It was expensive, impracticable, and imperfect, in that the whole surface of the body (with the exception of the head and a part of the neck) was exposed to subatmospheric pressure. Furthermore, it was soon discovered that successful operations *could* be carried out within the chest when the effects of opening the chest were compensated by forcing air under pressure through the trachea. This was accomplished first by the method of intratracheal insufflation,* but now the simpler method of inflating the lungs with pressure applied by means of a tightly fitting mask is more generally used.

Both intratracheal insufflation and the simpler method of positive inflation by means of a face mask are not without danger because both methods depend on an increase in intrapulmonary pressure and in this way presumably introduce some resistance to the passage of blood through the intrapulmonary vessels. Cotton and Boothby[14] warned of the danger of interference with the circulation by excessive intrapulmonary pressure soon after the method of Meltzer and Auer was introduced, and machines are now usually equipped with safety valves which may be set to blow off at any desired pressure. Although Cotton and Boothby stated that a pressure in excess of 10 mm. of mercury is unjustifiably dangerous, it is probably true that pressures considerably higher than this are not infrequently used in certain types of thoracic procedures.[15, 16] If the circulation is failing, it is conceivable that as little as 10 mm. of mercury pressure might introduce a vascular resistance which could not be overcome. The careless application of an excessive pressure at such a time would almost certainly stop the flow of blood entirely and lead to sudden death.

Our experiments were planned to shed light on one other question which until now has not been mentioned in the discussion, namely, *does*

*In 1909 Meltzer and Auer[12] introduced the method of intratracheal insufflation and were the first to demonstrate that ventilation of the lungs could be maintained and animals kept alive without respiratory movements. While they were testing and perfecting this method in experimental animals, Meltzer and Auer were concerned primarily with the maintenance of adequate ventilation and made no systematic study of the effect of the method on the circulation. It is of historical interest that intratracheal insufflation was soon adopted for the administration of ether anesthesia and first introduced into human surgery by Dr. Charles A. Elsberg of New York City.[13]

the alternate expansion and collapse of the lungs have a pumplike action and aid in propelling the blood? It is of interest to recall that Meltzer and Auer found in using insufflation in animals that the animals remained in better condition if the continuous air stream was interrupted once every three or four minutes,[12] and they advised that this be done in human subjects five or six times per minute for one or two seconds at a time.[13] Cutler[1] believes that the alternate expansion and collapse of the lungs aid the circulation. He has said, "It is as if the alternate distention and collapse of the lung acted somewhat as a pump, effecting not only a better circulation through the lungs, but probably in turn effecting also the ease with which blood gets out of the right heart and therefore, as secondary to it, leaving space for the entry of blood into the right heart."

On the contrary, Sahlin[17] has observed that patients treated in a "Barospirator"* a respirator, in which gaseous exchange is maintained without respiratory motion, show no signs of circulatory failure; and one of us (Moore[18]), has found that when the tidal air of one lung of a dog is decreased as much as 87 per cent, blood is not shunted to the opposite side. These observations suggest that lung motion in itself does not have an influence in propelling the blood, and this conception is supported further by the observations reported in this paper. After thoracotomy cardiac output did not show any significant change when intermittent inflation was replaced by continuous inflation, and vice versa. The results indicate indirectly that the only force of any importance in moving the blood through the lungs is the systolic contraction of the right ventricle.

If the decrease in cardiac output which accompanies thoracotomy and artificial respiration is due to the loss of intrathoracic "negative" pressure, as has been suggested, then the question naturally arises, why was not the decrease restored when the chest was closed and the animal allowed to breathe naturally again? Our experiments do not provide an answer for this question, but there are two theoretical explanations. It is possible that the damage done to the circulation was beyond repair in the short intervals of time which were allowed, and it is equally possible that the circulation to the heart muscle was so seriously impaired during the period of reduced output that myocardial damage followed. Beck and Isaac[7] observed a slow rate in recovery of cardiac output after exposure of the heart to positive pressure and suggested that herein may lie an explanation "for those fatalities in thoracic surgery that occur hours, or even a

*The entire patient is placed in a closed chamber, and the air content of the lungs is varied directly by using Boyle's law, according to which the gas content of a given space is proportional not only to the volume of the space, but also to the pressure in it, and can be varied with the latter as with the former. The variations of pressure within the chamber are brought about by changing the volume of the gas which it contains. Since there is no difference in pressure between the surface of the body and the interior of the lungs, both the lungs and the chest wall become motionless.

day or two, after the thoracic wound has been closed." In cases such as this the patients sometimes die with all the signs of circulatory failure and with no anatomical cause for death discovered at autopsy. Such fatalities, considered in relation to experimental studies, indicate that the chest cannot be kept wide open for long periods of time without serious risk of irreparable damage. In our opinion this risk can be attributed chiefly to circulatory failure and can be seriously augmented by increasing intrapulmonic pressure at a critical time. It is our belief further that prolonged operations on the chest, particularly those done on elderly people, are safer when the normal pressure relationships are maintained. Experimental studies suggest that this is one of the important factors of safety in the multiple stage thoracic procedures.

SUMMARY

Studies of the cardiac output have been made in a series of anesthetized dogs: first, during natural breathing, and, second, at varying intervals after wide-open thoracotomy and intermittent or continuous inflation of the lungs. It was found that:

1. Thoracotomy and intermittent inflation of the lungs were followed in every instance (8 animals) by a significant decrease in cardiac output.

2. The change in cardiac output was negligible when intermittent inflation was replaced by continuous inflation, and vice versa.

3. Complete restoration of the decrease in cardiac output did not take place in any of the animals when the chest was closed, but partial restoration occurred in three instances, these representing one-half of the animals in which the studies were repeated after closure of the thorax.

The decrease in cardiac output after thoracotomy and artificial respiration is assumed to be due to the elimination of intrathoracic "negative" pressure, which results in an impaired filling of the heart. The fact that cardiac output was essentially the same in the open chest preparation during intermittent or continuous inflation suggests that lung motion in itself does not have an influence in propelling the blood.

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ELECTROCARDIOGRAPHIC STUDIES OF A STAB WOUND OF THE HEART*

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A NUMBER of reports of electrocardiographic studies of stab wounds of the heart have appeared in the literature. Davenport[1] in 1924 was the first to report the appearance of a typical coronary type of curve following ligation of a branch of the left descending coronary artery and vein. Since that time there have been other similar opportunities to make electrocardiographic studies on operated stab wounds of the heart, and these reports may be found in the literature of Davenport and Markle.[2] The following case is presented as being of interest because it showed (1) the effects of pericardial tamponade and changes dependent on its relief and (2) the development of a typical electrocardiographic picture of recent coronary occlusion, which was silent clinically.

REPORT OF CASE

History and Examination.—E. W., a colored man, aged thirty-two years, was brought to the admitting room of Michael Reese Hospital on August 13, 1934, within ten minutes after a stab wound of the heart. The patient, while lying in bed, was stabbed with an ice pick in the left chest, 1 cm. below and medial to the left nipple. The patient presented the clinical signs of shock. The skin was cold, and the clothing was drenched with perspiration; pools of perspiration were present on abdomen and chest. Weakness was marked. Respirations were shallow with a rate of about forty per minute. The pulse rate was one hundred at the wrist, rapid and thready. A penetrating wound of the skin was found from which no blood was escaping at the time of examination; there was a considerable amount of blood on the patient's clothing covering the chest. Auscultation over the precordium revealed faint heart tones. The patient was taken immediately on a cart to the x-ray room, placed on the table in an almost upright position. The fluoroscopic examination was compatible with a pericardial sac effusion; although it is well known that it takes hours for distention of the pericardial sac. The costophrenic angles were not obliterated, and there was no fluid in the chest cavities. No distant heart plate was taken because of the patient's profound shock. The patient was then taken immediately to the operating room, and complete preparation of the entire chest for operation was made; then an electrocardiogram was taken (see A, Fig. 1).

Operation.—The operation was started immediately, local anesthesia (procaine 1 per cent solution) being employed. An incision was made over the left fifth rib anteriorly extending from the nipple line to the midsternum. The periosteum was stripped from the fourth and fifth ribs and a portion of these ribs extending from the anterior axillary line to the sternum was resected. Incision through the

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muscle was made, care being taken not to open the pleura. The left parietal pleura covering the pericardium was retracted laterally, exposing the pericardial sac. The internal mammary artery and vein were ligated above and below. The pericardial sac was grasped with forceps, lifted, and a 5 cm. horizontal incision was made. Blood gushed from the incision under considerable pressure, relieving the tamponade. At this point the patient volunteered the information that he felt re-

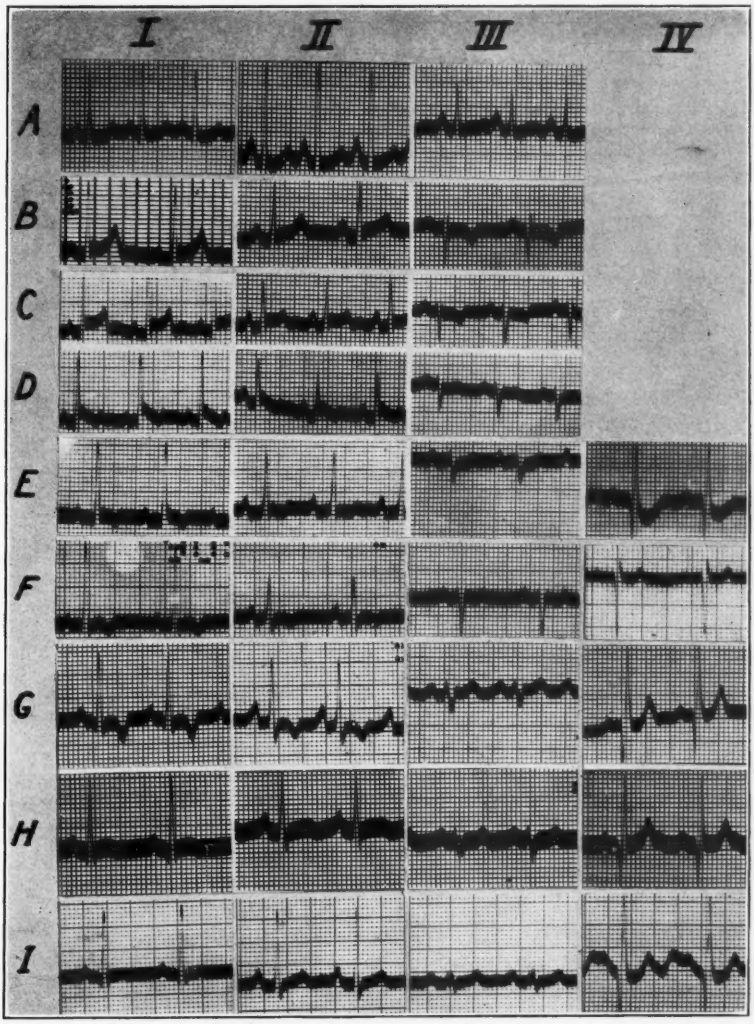

Fig. 1.—Segments of four lead electrocardiograms obtained at various times, to show the effect of pericardial tamponade and its relief on the electrocardiogram as well as the typical electrocardiographic progression of a clinically silent myocardial infarct in the anterior wall of the heart induced during the operation. Segment A, immediately before operation; B, five hours postoperatively; C, D, E, F, taken one, two, fourteen and twenty days postoperatively, respectively; G, H and I taken two, four and six months postoperatively.

lieved of the pain and sense of pressure over the precordium. The pericardial sac was cleared of blood and exploration made for the site of puncture in the heart. The puncture which caused the bleeding into the pericardial sac was found at the apex of the left ventricle and corresponded in size to the point of an ice pick. It was situated 1 mm. from the coronary artery and vein. The wound in the heart wall was not spurting blood, but it was considered advisable to suture the wound to prevent subsequent hemorrhage. Three sutures of black silk were placed in the heart with a curved needle. The first suture was left long as a guide. The other two were placed around the wound including the left descending coronary artery and vein, one above and one below. The stitches were placed during systole, and care was taken to avoid the endocardium. The parietal pericardium was closed with interrupted catgut sutures, and at the lower angle a small gutta-percha drain was carried out through the chest wall. The muscle was sutured with interrupted catgut sutures. The skin was closed with interrupted silkworm gut sutures and dressing applied. The patient withstood the operation well, and water in liberal quantities was given by mouth during the operation. The patient's pulse improved. The blood pressure following operation was 138/90 mm.

Postoperative Course.—On the day following operation there was considerable serous discharge from the drain, temperature was 101° F., and leucocyte count 29,450. The drain was pulled out in stages each day, until on the fourth day it was removed entirely. The patient developed a bilateral bronchopneumonia with a temperature of 105° and slight infection of skin wound, which drained. At this time the heart shadow was increased, probably because of myocardial weakness. The patient recovered and was discharged twenty-nine days after the operation. At this time the blood pressure was 130/96 mm. The pulse was regular and of good quality. The heart tones were of good intensity. The red blood count was 5,820,000 and the hemoglobin was 90 per cent. The patient showed a two-plus Wassermann. On leaving the hospital he went back to work, driving a truck and never complained of any disability. An x-ray film of the chest taken six months after the operation revealed no cardiac or pulmonary abnormality.

ELECTROCARDIOGRAPHIC CHANGES

The electrocardiograms of this patient are shown in Fig. 1. Record A was taken just before the operation. It shows a slightly negative S-T_1 and S-T_3, and upright T-waves and QRS complexes in all three leads. Record B was taken five hours after the end of the operation and shows the changes accompanying relief of the hemopericardium. S-T_1 and S-T_2 are now definitely positive, T_1 and T_2 have increased in size, T_3 is now negative, and a left axis shift has appeared. The changes are in accordance with those described by Katz, Feil and Scott[3] in pericardial tamponade.

Records C and D, taken twenty-four and forty-eight hours after the operation respectively, demonstrate the appearance of changes in the electrocardiogram associated with myocardial infarction. They show a progressive elevation of S-T_1 and S-T_2 and a change of T_1 and T_2 from a positive to a diphasic wave. T_3 shows a change in the opposite direction, namely, from negative to positive.

Record E, taken fourteen days after the operation, shows a further development of the T_1 type of Parkinson and Bedford[4] seen in recent

coronary occlusion. S-T_1 and S-T_2 are now less positive. S-T_3 has become negative, T_1 has become negative, T_3 has become positive. The changes are those described as occurring in coronary occlusion leading to anterior wall infarction. A fourth lead taken at this time demonstrates a markedly negative S-T_4. T_4 was not visible. In record F, S-T_4 has become isoelectric and T_4 small and positive. T_4 waxes in record G. At the same time, QRS_4 changes from diphasic to a mainly inverted form in record F and returns to its former shape in record G. These changes are similar to those described recently by Katz and Kissin[5] and Katz and Bohning.[6]

Records F and G show the typical progression seen in recovery from coronary occlusion. The T-wave is waxing in all three leads, becoming more negative in Leads I and II and more positive in Lead III.

Records H and I, taken respectively about four and six months after the injury, show recession of the changes. The T-wave is waning and remains small and inverted in Lead I, becomes positive in Lead II, remains positive in Lead III. The left axis shift has lessened considerably. In Record H, T_4 is also waning. The last two records (H and I) are now within normal limits except for the positive T_4. The undulations of the curve in Lead IV of record I is an artefact due to mechanical action of the contracting heart in displacing the chest electrode. This is possible because of the absence of ribs over the point of application.

This series of curves demonstrates the appearance and disappearance of the electrocardiographic changes due to an artificially induced infarct of the heart wall. In addition, the record before operation shows the marked changes produced by tamponade and the record following the immediate change on its relief.

The Q and T types found agree with the Q_1 type of Wilson and his coworkers[7] and the T_1 type of Parkinson and Bedford.[4] These types are often found with anterior wall infarction.

The changes in the fourth lead in such an induced infarct are described for the first time. They are of a type described by Katz and Bohning[6] in infarction of the anterior wall of the heart, i.e., an early depression of S-T_4 with a later regression and the appearance of a positive T_4 which waxes and wanes. The value of the fourth lead is shown by the persistence of abnormality in Lead IV when the standard three leads have returned practically to within normal limits.

It is interesting to note that such electrocardiographic changes typical of myocardial infarction occurred in the absence of clinical evidence of this condition. There is a tendency on the part of some to consider all instances of recent coronary occlusion as of serious moment. This case shows that such an occurrence with typical electrocardiographic findings may appear in a clinically silent form.

SUMMARY

A case is presented of stab wound of the heart requiring operative intervention. In this patient, four lead electrocardiograms were obtained. The records showed the effect of pericardial tamponade and its relief by surgery. They also showed the typical progression of changes seen in infarction in the anterior wall of the heart, in this instance produced by ligation of the left descending coronary artery and vein at operation. These electrocardiographic changes of infarction were not accompanied by clinical signs.

We are indebted to Dr. L. N. Katz for his advice and criticism in the preparation of this report.

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Department of Reviews and Abstracts

Conducted by Duff S. Allen, M.D., Associate Editor

Selected Abstracts

Induced Deposition of Calcium in the Human Lung. R. A. Hunter. Tubercle **16**: 489, 1935.

The author describes a case of pulmonary tuberculosis with a bronchial fistula in which gelatine acriflavine calcium chloride was injected intrapleurally with the formation of hyaline change followed by calcification, the medium having passed through the fistula into the lung parenchyma.

Calcareous changes were also noted in the thickened visceral pleura. The pleura was too hyperplastic to permit of any apparent infiltration of this medium into the lung parenchyma directly.

It is suggested that there is no fundamental difference between connective tissue hyaline change and the associated homogeneous colloidal mass except probably the character of the tissue immediately prior to conversion. These findings are in accordance with experimental work on tuberculous infected animals.

The employment of this medium is suggested in cases of pleuropulmonary fistula; tuberculous glands, bones, bowel, and throat; and for intrapulmonary treatment of patients presenting localized tuberculous lesions.

H. L. Cabitt.

The Limitations of Oleothorax. L. Opengame. Tubercle **16**: 508, 1935.

The author asserts that there are fewer indications for the use of oleothorax now than formerly because of the perfecting of the technic of pneumothorax treatment and the improvement in thoracoplastic surgery.

There are still three main indications for oleothorax: (1) to obtain more compression than has been attained from a pneumothorax, (2) to obtain more mechanical collapse than that derived from pneumothorax, (3) as an antiseptic measure in certain pleurisies. Oleothorax is also of benefit in mediastinal hernia.

He uses mineral oil for a more mechanical and a more compressible collapse, and vegetable oil for pleurisies. Mineral oil is not so rapidly absorbed as gomenol but gomenol is more antiseptic.

He stresses the danger of overpressure with the use of oleothorax, since it leads to perforation of the pleura. These perforations are often fatal.

H. L. Cabitt.

Stab Wounds of the Heart. John D. Koucky and George Milles. Arch. Int. Med. **56**: 281, 1935.

The authors report a case of stab wound of the heart, with recovery. Complete electrographic studies and their comparison with similar studies show that a Pardee curve, replaced after about ten days by an inversion of the T-wave, occurred in all cases. Usually there is a complete return to the normal curve.

This case was complicated by a polyserositis which may have resulted from the use of surgical solution of chlorinated soda in irrigating the pericardial sac after the development of pericarditis. The mechanism of the development of polyserositis is discussed.

Roentgenographic visualization of the pericardial sac after injection of an iodized and chlorinated peanut oil was carried out. The pictures disclosed little obliteration of the pericardial sac.

The operation performed without anesthesia or anything more than the most cursory attempts at sterility, necessitated by the extreme state of the patient, resulted in ultimate and complete recovery.

H. L. Cabitt.

The Production of Collateral Circulation to the Heart. Claude S. Beck and V. L. Tichy. Am. Heart J. **10**: 849, 1935.

The heart, to a marked degree, is unable to develop an adequate collateral blood supply to meet an emergency as coronary occlusion. If life is preserved over a sufficiently long period of time, the myocardium can draw from other sources for its blood supply. The heart has three sources from which to receive its blood supply: (1) coronary arteries, (2) thebesian vessels, (3) extracardiac anastomoses between the coronary system and the blood vessels in the fat and other tissues at the base of the heart. Blood vessels have been proved in adhesions between the heart and the pericardium.

The problem of producing a new blood supply to the heart resolved itself into two components. First, to make available a satisfactory vascular bed for the heart. The available bed for vascularization of the myocardium consists of pericardium, pericardial fat, mediastinal tissues, pleura, diaphragm, substernal muscles, musculature of the thoracic wall and omentum. In the experiments of the authors, all

on dogs, the first three structures were utilized. A direct continuity between the vascular bed and the heart was obtained by the production of adhesions.

The second component of the problem was to produce the stimulus to bring about continuity between the cardiac and the extracardiac vascular beds. This stimulus was a reduced or subnormal pressure in the coronary bed which was obtained by occlusion of the coronary arteries.

The authors found that vascularization of the myocardium from the collateral bed was slight or absent if the coronary circulation was normal. Thus, blood vessels grow into the myocardium when the latter has need for a greater blood supply.

They have been able to obstruct or destroy most of the arterial coronary circulation and have new collateral circulation develop. Partial occlusion of the coronary arteries is better tolerated if the heart is given a collateral bed at a previous operation. The direction of flow in the vascular bed is toward the heart. The collateral bed is effective in bringing an even distribution of blood to various areas of the myocardium, this effect being accomplished in two ways: (1) by supplying the myocardium with blood from extracardiac sources, (2) by transporting blood from a region of the myocardium that has an adequate blood supply to another region deficient in blood supply.

The authors describe the technic of the various operations.

Henry L. Cabitt.

Pulmonary Abscess and Pulmonary Gangrene. B. S. Kline and S. S. Berger. Arch. Int. Med. **56**: 753, 1935.

The authors report 55 cases of pulmonary spirochetosis (Miller-Vincent's infection of the lung) including 39 cases of pulmonary gangrene, 12 cases of bronchogenic pulmonary abscess, 23 cases of embolic pulmonary abscess.

The embolic abscesses were associated with suppuration elsewhere in the body and were manifestations of generalized pyemia or bacteremia. In this group there was a mortality of 96 per cent. In the bronchogenic pulmonary abscess group which usually followed pneumonia or operation there was a 58 per cent mortality. Of local bronchogenic pulmonary lesions, gangrene was three times as common as abscess. Twenty-three cases of gangrene followed operation, mainly under general anesthesia, and one-half of the operations were on the oral cavity. The mortality in the gangrene group was 49 per cent. In those cases of gangrene which were treated properly the mortality rate was 32 per cent. The authors state that it is relatively simple to differentiate between pulmonary gangrene caused by spirochetes, fusiform bacilli and vibrios, from pulmonary abscess produced by

pyogenic organisms. There is a distinct difference between these two lesions in respect to the appearance and character of the sputum, and autopsy findings.

Arsphenamine therapy has been shown to be efficacious in pneumonitis with sputum containing Miller-Vincent's organisms, especially where gangrene has resulted. Seventeen of 25 patients with this type fully recovered from the disease. In addition to the use of arsphenamine, wherever necessary, transfusions, high calorie diet, and oxygen therapy are utilized. Postural drainage is routine in the treatment of pulmonary abscess, and bronchoscopic drainage is useful in the early stages of cavitation. If gangrene of the lung results in cavity formation and no healing takes place with conservative measures in four to eight weeks, then healing is unlikely and the chronic stage is present. Thus, when chronic pulmonary suppuration is present, in certain cases pneumothorax or phrenicectomy is done; in other cases the open operation is resorted to, the operation being that of cautery pneumectomy or lobectomy.

The authors discuss the occurrence of the Miller-Vincent organisms in the mouths of healthy individuals, and they show that proper oral hygiene can prevent resulting infections. Miller-Vincent's organisms and infections are seven times as common in adults as in children. Pulmonary abscess due to pyogenic organisms is three times as common in children as in adults.

The authors discuss the bacteriology of the Miller-Vincent organisms and believe that the vibrio is the symbiotic agent making possible the growth of anaerobic oral spirochetes and anaerobic fusiform bacilli in the mouth and elsewhere.

Henry L. Cabitt.

The Treatment of Bronchial Asthma by Dorsal Sympathectomy. G. L. L. Levin. Ann. Surg. **102**: 161, 1935.

The author disagrees with the current opinion that the vagus nerve is the constrictor bronchial nerve, citing reasons from an evolutionary point, from cases in which vagal irritation gave typical vagal phenomena but no asthma, and showing that stimulation of the vagus results in the liberation of acetylcholine around the vagal nerve endings, acetylcholine being a depressor and relaxing agent. He believes that the constrictor fibers are contained in the sympathetic trunk.

There is sufficient evidence to show that the dorsal sympathetic nerves, especially the second to the sixth rami, contain both contractor fibers to the bronchial musculature as well as sensory bronchial fibers. Both the rami and the thoracic trunk are accessible for either neurectomy or neurolysis by absolute alcohol. Bronchial sympathetic

neurolysis by absolute alcohol has resulted in complete relief in 75 per cent of cases of severe intractable asthma treated.

On the Demonstration of Particles of Malignant Growth in the Sputum by Means of the Wet-Film Method. Leonard S. Dudgeon and C. H. Wrigley. J. Laryngol. & Otol. **50**: 752, 1935.

The authors examined the sputum from 58 cases of suspected malignant growth of the lung or respiratory tract by the wet-film method, which is described. In 68 per cent of the proved cases of carcinoma of the lung or larynx they could make a diagnosis from the examination of the sputum and in a majority of the cases the histologic type of growth could be distinguished. In many cases perfect specimens of particles of malignant growth were obtained, and the histologic features were described in detail. A description is given of the characteristic appearance of inflammatory and "scavenger" cells as seen in the preparations. On one occasion a mistaken diagnosis of malignant growth was made and later was proved to be inflammatory in nature.

Henry L. Cabitt.

Trauma and Tuberculosis. Edgar Mayer. New York State J. Med. **35**: 1024, 1935.

The author states that under exceptional conditions, trauma may undoubtedly introduce tuberculous infection into the body. As a rule trauma reopens a healed lesion, unmasks a latent lesion, or aggravates a manifest lesion. Pulmonary tuberculosis may arise following mechanical, physical or chemical lung injuries. Pulmonary tuberculosis more often follows violent trauma applied to the body or chest than penetrating injuries to the lung. Lesions of tuberculosis may be found at the site of chest injury, but far more often they appear in the upper portions of the lungs just as tuberculosis commonly does. This means that one is dealing with an exacerbation or reactivation of a preexisting apical lesion. The medicolegal evaluation depends upon (1) the nature and severity of the trauma, (2) the age and condition of the patient before the trauma, (3) the time element and undisputable linkage of symptoms and the first appearance of lesions with their traumatic origin.

Henry L. Cabitt.

Book Review

SURGICAL DISEASES OF THE CHEST. By Evarts Ambrose Graham, Jacob Jesse Singer, and Harry C. Ballon. With 637 engravings. Philadelphia, 1935, Lea & Febiger.

This book is by far the best single treatise on the surgery of the chest. It is destined to be for many years the thoracic surgeon's bible. Whatever developments of chest surgery the future may bring, this work will maintain permanent value.

The authors' position, experience, their predilection for physiologic investigation, and their uncommonly sane clinical judgment have enabled them to speak with an authority, for which their names stand sufficient guarantee. But the book is more than a pronouncement of the authors' own opinions—valuable and interesting as such a personal record may be. It is made most useful by Graham's wide bibliographic training and experience. His editorship of numerous journals and yearbooks has given him an oversight into the literature and a knowledge of the work and opinions of other workers in his field which have made this book a rare combination of authoritative personal dicta and complete knowledge of the work of others. Although some of the chapters are short, the bibliographies are excellently well chosen and the statistical tables, one hundred forty-nine of them, are invaluable, so that whatever is lacking may be easily run to ground in the literature.

It is not possible in the short space of a review to recapitulate the contents of this work; it is extraordinary how much it compresses into so small a compass. The first chapter deals with a few selected topics on the physiology of respiration. The second chapter is an all too brief one on endotracheal anesthesia. A more elaborate discussion of various methods of anesthesia, their use, their advantages and disadvantages in chest surgery, including avertin, evipan, the new semivolatile ethers, spinal and local anesthesia, would be of interest and value, for no one factor is more important in determining the success of a chest operation than the anesthetic.

There follow chapters on postoperative pulmonary complications, the rib cage, the pleura, and the mediastinum. In the chapter on the rib cage one misses a discussion of scoliosis and other postoperative deformities. The heart and the pericardium are well discussed, and there is an excellent chapter on esophagoscopy and bronchoscopy from the pen of David Ballon. The chapter on bronchiectasis is outstanding.

The Matsons have contributed two valuable and complete chapters, one on intrapleural pneumolysis and one on oleothorax. In the other chapters on pulmonary tuberculosis one might wish for further discussion of the application of various surgical methods to the various anatomical manifestations of tuberculous disease, further elaboration of indications for the various methods of treatment and a statistical appraisal of the results of conservative as compared with surgical treatment.

Curtailment of some of the experimental protocols, a condensation of some of the case histories, and elimination of some of the full page cuts of experimental animals might be no great loss if it were desirable to expand the book in other directions without increasing its volume.

The book needs no bush for the chest surgeon. It is to be hoped that his medical confreres will read it with equal avidity. They cannot fail to profit by it, for like Gray's *Anatomy,* Oppenheim's *Neurology* and Osler's *Medicine,* it is one of those few trustworthy storehouses from which no seeker will ever turn away disappointed and empty-handed.

Leo Eloesser.

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BRUNN, HAROLD----384 Post Street, San Francisco, Calif.
BUTLER, ETHAN F.----370 West Church Street, Elmira, N. Y.
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CARTER, B. NOLAND----Cincinnati General Hospital, Cincinnati, Ohio
CHURCHILL, EDWARD D.----Massachusetts General Hospital, Boston, Mass.
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COLE, DEAN B.----Professional Building, Richmond, Va.
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DECKER, HARRY R.----923 Westinghouse Building, Pittsburgh, Pa.
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FAULKNER, WM. B. ----St. Mary's Hospital, San Francisco, Calif.
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FISCHER, HERMANN----35 East 84th Street, New York, N. Y.
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HARRINGTON, STUART W.----The Mayo Clinic, Rochester, Minn.
HART, DERL----Duke Hospital, Durham, N. C.
HARVEY, SAMUEL----New Haven Hospital, New Haven, Conn.
HEINBECKER, PETER----Washington University Medical School, St. Louis, Mo.
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KINSELLA, THOMAS J.----Glenn Lake Sanatorium, Oak Terrace, Minn.
LAMBERT, ADRIAN V. S.----768 Park Avenue, New York, N. Y.
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BISGARD, DEWEY----------University of Nebraska, Omaha, Neb.
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BRADSHAW, HOWARD H.----------Massachusetts General Hospital, Boston, Mass.
CARLSON, HERBERT----------University of Minnesota Hosp., Minneapolis, Minn.
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TUTTLE, WM. M.---Detroit, Mich.
VAN HAZEL, WILLARD---1819 Polk Street, Chicago, Ill.
WEINBERG, JOSEPH A.---107 S. 17th Street, Omaha, Neb.
WOODRUFF, WM. WARRINER---18 Church Street, Saranac Lake, N. Y.

Senior Members

BRANOWER, WILLIAM---285 Central Park, West, New York, N. Y.
BROWN, LAWRASON---24 Church Street, Saranac Lake, N. Y.
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CRUMP, ARMISTEAD---20 West 50th Street, New York, N. Y.
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GEORG, CONRAD, JR.---117 East Liberty Street, Ann Arbor, Mich.
GREEN, NATHAN---New Canaan, Conn.
HITZROT, JAMES---126 East 37th Street, New York, N. Y.
JACKSON, CHEVALIER---3432 North Broad Street, Philadelphia, Pa.
KENYON, JAMES---22 East 69th Street, New York, N. Y.
LEMON, WILLIS S.---510 Tenth Avenue, S. W., Rochester, Minn.
MCSWEENEY, E. S.---132 East 64th Street, New York, N. Y.
MANGES, MORRIS---43 West 85th Street, New York, N. Y.
MILLER, ROBERT T., JR.---9 East Chase Street, Baltimore, Md.
PLUMMER, HENRY S.---The Mayo Clinic, Rochester, Minn.
POOL, EUGENE H.---107 East 60th Street, New York, N .Y.
SMYTH, JOHN---921 Canal Street, New Orleans, La.
STEWART, WILLIAM H.---222 West 79th Street, New York, N. Y.
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WATSON, EVERETT E.---Mt. Regis Sanatorium, Salem, Va.
WHIPPLE, ALLEN O.---180 Fort Washington Avenue, New York, N. Y.

WHITTEMORE, WYMAN.....199 Beacon Street, Boston, Mass.
WILMS, J. H.....12 West 7th Street, Cincinnati, Ohio
YATES, JOHN L.....141 East Wisconsin Avenue, Milwaukee, Wis.

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	H. H. JANEWAY		CHARLES LOCKWOOD
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1922	HENRY L. LYNAH	1934	CARL A. HEDBLOM
1923	WILLIAM S. HALSTEAD		ALEXIS VICTOR MOSCHCOWITZ
1927	SPARRELL S. GALE		RAY MATSON
	FRED W. PARHAM	1935	WILLIAM FRANCIS HONAN
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1922	SAMUEL ROBINSON, Santa Barbara		
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1924-1929 ETHAN FLAGG BUTLER, Elmira, N. Y.
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Meeting Dates

1918	Chicago, June 10	1927	New York, May 9
1919	Atlantic City, N. J., June 9	1928	Washington, D. C., April 30
1920	New Orleans, May 1	1929	St. Louis, April 25
1921	Boston, June 6	1930	Philadelphia, May 12
1922	Washington, D. C., April 29	1931	San Francisco, July 1
1923	Chicago, May 28	1932	Ann Arbor, Mich., April 18
1924	Rochester, Minn., June 5	1933	Washington, D. C., May 9, 10, 11
1925	Washington, D. C., May 4	1934	Boston, May 31, June 1, 2
1926	Montreal, P. Q., September 30	1935	New York, June 3, 4, 5

American Association for Thoracic Surgery to Meet in Rochester, Minn.

The Nineteenth Annual Meeting of the American Association for Thoracic Surgery will be held in Rochester, Minnesota, on May 4, 5, and 6, 1936.